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MINE AND QUARRY

Modern Methods at an Illinois Mine

Cleaning Granite by Compressed Air

The Power Extension at the

MINE AND QVARRY

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1906-1911

SULLIVAN ROCK DRILLS IN THE BAS OBISPO CUT, PANAMA CANAL

Modern Methods at an Illinois Mine

Cleaving Granite by Compressed Air

The Power Extension of the Chicago Drainage Canal

PUBLISHED BY THE SULLIVAN MACHINERY CO. RAILWAY EXCHANGE BUILDING, CHICAGO

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Two views of the Bas Obispo Cut: Sullivan Drills at work

Bas Obispo Cut: Sullivan Drills in foreground. Steam shovel in bottom of cut; Churn Drill in background

The Culebra Cut, North End

Workmen's Quarters, Culebra

ROCK EXCAVATION AT PANAMA

[illegible] Z. Panama,
March 15 1906.

Mines and Minerals

In reply to your inquiry as to the amount of rock work being done upon the canal I may say that rock excavation is in progress at several different points between Las Obispos and Pedro Miguel. The most important undertaking from the point of view of the amount and hardness of the rock to be removed is that at Las Obispos. At this point 24 Sullivan tappet valve drills, class DH 11, with 3½ in. cylinders, have been in use for the past six months, drilling holes from 20 to 27 ft. in depth, together with three churn drills used to handle a few holes from 50 to 60 ft. deep on the upper benches. This Las Obispos cut, begun by the French and now being greatly widened and deepened by the Americans, is an all rock formation, hard and blocky, making it difficult to drill. Our frontispiece shows the Sullivan drills at work in this cut and several photographs reproduced herewith illustrate further the operations at Las Obispos. Etc.

From Las Obispos going south along the line of the canal no heavy rock is encountered till the Culebra cut is reached. At Empire, however, some few miles this side of Culebra, at present 15 steam drills are at work in a soft rock formation, widening the old canal and at about the same point some twenty five churn drills are working, principally where clay is encountered and where the latter runs to a depth of 17 ft.

At the present time no steam drills are at work in the Culebra cut, although some hand drilling is being done on a section of rock pitch at a point 60 degrees from the horizontal. The class of formation met with in this cut is extremely varied, a large percentage of it however, being rock as soft as soapstone in places and like a trap rock in others, with an occasional vein of quartz. Below Culebra a few steam drills are at work near Paraiso, the same drills just having finished drilling in the rock section at Pedro Miguel.

The air operating drills in use, some 65 in number, are all at the present time operated by steam, which power will later on give place to electricity when the air compressor installations are complete and the necessary pipe laid.

Hoping that this information will be of interest I remain

Yours truly,
[illegible] W. Hanavan.

MODERN METHODS AT AN ILLINOIS MINE

[illegible]

The [illegible] operations are as well worked a body of coal as can be found in the coal industry anywhere and the two mines which are constantly going upon the shipping

Tipple, Power House and Fan House, St. Louis & O'Fallon Coal Co.

basis, bear witness in their economical management and splendid equipment, to the enterprise and foresight of their owners. The No. 2 mine of the St. Louis and O'Fallon Coal Co., near East St. Louis, is an excellent example of late practice in this respect. The company's general offices are in the Missouri Trust Bldg., St. Louis, and its officers are, Mr. Jas. M. Browning, President, Mr. L. A. Browning, Vice President, Mr. C. A. Wall, Secretary and Treasurer, and Mr. John T. Taylor, General Manager at East St. Louis.

The company has for some time been operating mine No. 1, which is now shipping between 1,700 and 1,800 tons per day. All coal at this mine is won by hand work. In opening mine No. 2 it was desired to make the mine one of the largest in the state, and to produce fuel of as high a grade as possible, for the market. In order to accomplish these results, the company has spared no pains or expense in their manner of opening the mine, or in installing equipment of the most improved type.

Page 4 shows the power plant, fan house, head frame and tipple, with the machine shop and store house in the back ground. The buildings are of heavy brick and steel girder construction, the roofs and siding for the tipple and head frame, being of corrugated iron. The stack shown, is 90 ft. in height.

The vein (see page 5) is 7 ft. in thickness, of a high grade of standard Illinois coal. It is reached by two shafts (with two compartments each), 18 feet by 9 feet in the clear and 206 ft. deep, one for hoisting and one for ventilating purposes. The roof over-lying the coal is composed of 17 ft. of hard black rock, on top of which slate and shale occur. Props are seldom needed. The entries are driven 20 ft. in width, and the rooms are 35 ft. wide. The track gauge of the mine is 42 in., and 42 pound rails are used throughout. At present mule haulage is in use, but will be replaced by electricity as soon as the mine is sufficiently opened up. The pit cars have a capacity, when loaded level, of 2½ tons, but in practice are loaded to 3½ or 4 tons on the aver-

Seven Foot of Good Coal

age, as shown by the tally sheets of the weighmen.

In order to secure the greatest possible amount of lump, the coal is not shot from the solid as in mine No. 1, but is undercut throughout by pick mining machines of the Sullivan class 5 type. These machines undercut the coal to a depth of 5½ ft., and thus make it possible to shoot the coal satisfactorily with a very light charge of powder. Page 6 shows one of these machines at work undercutting and on page 8 is shown a room which has been cut and is ready for shooting. These undercutters have a 5¼ in. cylinder, and weigh 825 pounds. This particular type has been very generally adopted in Illinois mines, and has proven very economical of power and repairs and convenient to handle. By their use it is possible to open up a mine nearly three times as rapidly as by hand. They are operated double shift, thus providing a constant supply of coal as great as the loaders can handle. These machines average from 70 to 75 tons per shift of 8 hours in coal of this height, i. e., 6½ to 7 ft. An expert runner, however, recently cut 1382 tons in 12 eight-hour shifts. The pick machines are supplied with air from two Sullivan straight line air compressors (see below) furnishing at their rated speed of 100 R. P. M., approximately 5,000 cu. ft. of free air per minute. These compressors, as well as the pick machines described above, are manufactured by the Sullivan Machinery Co., of Chicago. The compressors have 28 in. simple steam cylinders, and the air is compressed in two stages, the cylinders being 30 in. and 18 in. in diameter respectively, with a common stroke of 30 inches. The steam slide valve gear is controlled by a Meyer adjustable cut-off with Richardson balance. The free air supply is conducted from outside of the engine room to the compressors so as to secure freedom from dust and moisture, and enters both the high

The Sullivan Straight Line Air Compressors

Sullivan Pick Machine at Work, St. Louis & O'Fallon Coal Company

and low pressure cylinders through rotary or Corliss valves positively driven from an eccentric pin on the engine shaft. These valves afford a wide direct opening to the cylinder and operate very quickly so that the air has no opportunity to become heated in entering the cylinder and clearance losses are minimized. Heating of the air during compression is further guarded against by heavy water jackets on the cylinders and cylinder heads and by a large intercooler in which the air meets the cold water tubes three times in passing from the low to the high pressure cylinder. Self acting poppet discharge valves are employed on air so as to reduce clearance losses to the minimum and removable by hand for inspection. The air discharge pipes from both compressors are 7 inches in diameter and meet in a single pipe 9 inches in diameter leading to the receiver. The receiver is located outside the engine room and is of the horizontal type, 36 inches in diameter by 30 ft long. Gate valves between the compressors and receiver permit the cutting out of either compressor if desired. The main pipe line running from the receiver to the bottom of the shaft is 10 inches in diameter. It is here divided into two six inch lines, each six inch line running into a 36 inch by 16 foot horizontal receiver, at this point to allow avoiding all fluctuations in pressure at the machines and effectually removing entrained water. To accomplish the latter purpose, additional water traps are placed at several points along the pipe lines. A six inch line comes out of each receiver extending along the main entry. The cross entry pipes are three inches in diameter and the main pipes supplying the machines are one and one half inches thus providing amply against loss in pressure due to friction.

In order to secure the large output [illegible] per day and to handle the unusually large pit cars referred to above, a hoist was installed with seven ft winding drums and two engines with 24 x 36 inch cylinders having a capacity of 1,000 tons per day. The electric ventilating fan is in a separate building to the extreme right in the cut on page 6, and is 22 ft in diameter, which is more than adequate for any extent to which underground workings may be carried. Power for the hoist fan compressors etc is supplied by two batteries of horizontal tubular high pressure boilers representing a total horse power of 1,200.

For carrying out the object of the company to have as large a capacity of as high a grade of product as possible the design of the tipple and screens is particularly noteworthy. This portion of the plant was designed and erected by Roberts & Schaefer Co consulting and constructing engineers of Chicago. The lower portion of the tipple

down to the line of offset on the ground, shown in the cut on page 4, is built entirely separate from that portion of the tipple over the railroad tracks, which supports the screens, so that the vibration from the cables is not transmitted through the tower to the screens, nor is vibration from the screens carried through their supporting structure back to the tower. This structure, as well as that of the tipple, is entirely of steel and is made very

A Machine Mined Room Ready for Blasting

heavy and substantial, of abundant size to accommodate the heavy screens, and to leave room for the workmen. The structure is very carefully braced, and hardly any tremor is noticeable at any part of it, even when the apparatus is running at full speed. The portion of the tipple supporting the screens is also strengthened and stiffened by an independent set of braces similar to the main engine braces, which run down to independent foundations near the shaft.

Another special feature of this plant is the wide shed on either side of the tipple, covering all four railroad tracks. These sheds, together with the width of the tipple, give a total length on the tracks of 77 ft., enabling the car trimmers to work under cover at all times. The screening and weighing plant makes it possible to obtain perfect sizing and to load the coal into the cars with the least possible breakage, so that having so mined the coal as to secure the highest possible percentage of large sizes, it may be possible to bring the product to the market without nullifying this advantage. On account of the extraordinary size of the pit cars, it was necessary to have a very large weigh hopper, and the method of operating the weigh hopper door can readily handle this large quantity of coal. There is a double chute just below the self-dumping cages, into which the cars from both compartments of the shaft are dumped. This chute tapers from a width of 17 ft. at the top to about 15 ft. at the bottom. This weigh hopper will hold at least three pit cars of coal or a maximum of 12 tons. This chute is on a scale frame and the scale beam for it is in the weigh house just above the weigh hopper. The door to this hopper is opened by a steam jack, which can be operated slowly to discharge this large quantity of coal very gradually onto the screens. These screens are 56 ft. by 9 ft. in size, made in two sections and hung from the structural

Rock Excavation on Upper Headrace, Chicago Drainage Canal

between 17,000 and 18,000 feet for the purpose of determining the extent of known ore bodies and prospecting new ground. The B. C. Copper Company, during the last twelve months, has drilled between 3,000 and 4,000 feet in its Mother Lode mine, and recently commenced using the drill in the Emma mine, also in this district. The Dominion Copper Company is preparing to put in a number of drill-holes from the lower levels of its Brooklyn mine at Phoenix. Drills have also been used for prospecting purposes in the Oro Denoro, the Betts and Hesperus mines."

Diamond drill work in the Transvaal at great depths, continues active. A bore-hole sunk at an angle of 45 degrees from the foot of the Cinderella shaft, near Johannesburg, encountered the Main Reef at a vertical depth at 3,980 feet from the surface. Six feet of the quartz core assayed 20.56 dwt. per ton, with 92.78 dwt. in the 15 inches next the foot wall. The deepest bore-hole on the Rand reached ore at 5,582 feet; this depth, however, will soon be surpassed, if the present

Sullivan "H" (1,000 foot) Drill, in Calumet & Arizona Mine

200 feet. The grade of the canal is one foot in 20,000.

A canal boat lock is provided for, 46 feet in width, by 136 in length, at the power house, to handle the traffic now carried on the old Illinois and Michigan Canal, and an 80 by 600 foot ship canal lock is also planned, to be built when arrangements for the waterway to the Mississippi are completed. A bear trap dam will regulate the flow of water. The general arrangement of these projects is shown in the drawing on page 14.

The present extension is divided into three sections (a) the headrace, 10,700 feet long, with minimum depth of 22 feet and 160 feet in width; (b) the power house, 386x159 feet in size, and two stories high; (c) the tailrace, 6,800 feet long and of the same width and depth as the headrace.

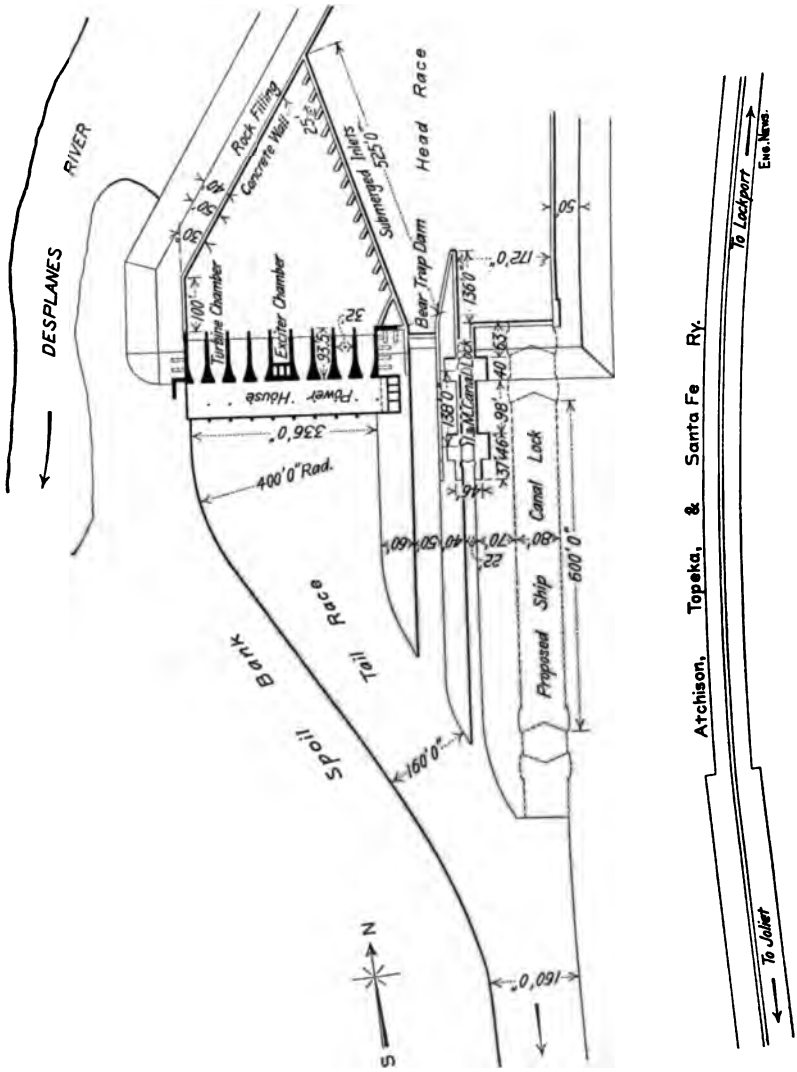
The entire work comprises 105,000 yards of earth removal, 1,273,540 cubic yards of rock excavation, 366,484 cubic yards of earth embankments, 977,084 cubic yards of rock embankment and 150,000 yards of concrete.

Work was begun early in 1904, and the developments described in the present article will be completed late this year. Owing to the delay and cost of condemnation proceedings, the widening of the Chicago river may not be finished at this time. The present flow of water will generate 20,000 horse power at the dynamo. The canal boat lock and the new bear trap dam are but just begun, contracts for the work having only recently been let.

HEADRACE.

The headrace is excavated entirely through rock, the spoil being used to form a heavy earth and masonry embankment or levee upon the right side of the channel, and a concrete wall supported by rock fill, upon the left side. The cut on page 10 shows the character of the work.

The engineer's specifications provided that the rock walls of the channel should be cut true to line before any of the material within was blasted or removed. This work was accomplished by the use of four standard Sullivan class "Y" stone channeling machines, of the rigid head type, with boilers. These channelers make a vertical rock wall cut from 9 to 12 feet in depth, and are similar to those used in 1893-4-5, on the main canal. A solid Z shaped bit was used, instead of the five-piece gang bit customary in quarry service, in order to avoid the danger of sticking in the seamy Joliet limestone. By adopting this method of outlining the canal the engineers secure a smooth wall, unshattered by explosions, which will remain firm and impervious to weather as long as the work is in use. As the walls are true and accurate, no extra trimming or filling was required to bring them to line, as would have been the case if blasting had been adopted. The accompanying photograph



Turning basin, dam, locks and plan of power house. From a drawing furnished by the Sanitary District

One of the Concrete Mixing and Elevating Machines used in Building the Retaining Wall

channel by the typical excavation methods employed on that work, and was kept well back of the line of the rear face of the wall. As the latter is completed the embankment is brought to grade between the part built first and the wall, from trestles, with material hauled from the tailrace. This wall is 6 ft. thick on top and 16 ft. at the bottom, and varies from 25 to 38 ft. in height.

Two large movable plants for mixing and elevating the concrete to position were built by the contractor, as illustrated in the accompanying photograph. These plants are each built upon two flat cars placed side by side. A 100 horse power boiler and engine are mounted on these cars and transmit power for moving the cars along the track and for the concrete mixers, hoisting derricks, etc., by means of a line shaft and

The Sullivan Channeler excavating one of the Turbine Wheel Pits

friction clutches. There are three floors or stories; the top floor receives the broken stone, screenings and cement. The latter two materials are dumped into hoppers leading to a dry concrete mixer on the first floor, on the car next the wall, the outer car being occupied by the boiler and engines. Thence the mixture passes by bucket elevators to two wet mixers, on the second floor, where it is combined with the broken stone and is thence carried to place in the wall by inclined bucket elevators. These two plants mixed and placed 100,000 cubic yards of concrete during the last season, or an average of 300 yards each per 10-hour shift.

POWER HOUSE.

The arrangement of the power house, forebay, turning basin, dam and locks, is shown by the accompanying drawing, page 14. The concrete wall running diagonally across the basin from the outer end of the dam forms the head bay, and has submerged openings or inlets, the intrados of the arches being 12 feet below Chicago datum (low water level of Lake Michigan of 1847). This will protect the water wheels from floating ice and drift, which will be discharged over the bear-trap dam.

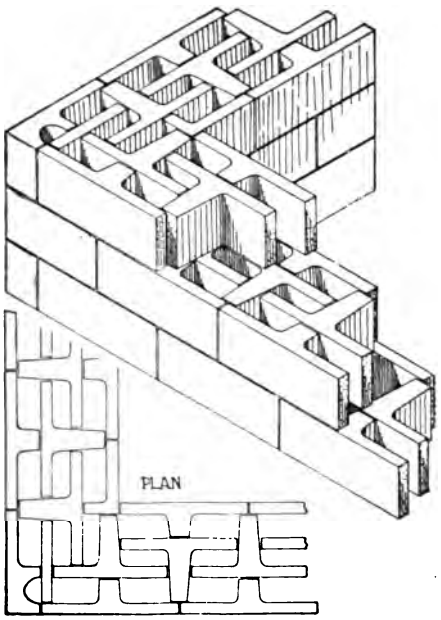
There are eight wheel pits and one exciter pit, divided into three compartments. The wheel pits are 115 feet in length, and range in width

Two of the Pits, with Palse Work for Walls and Turbines

from 7½ feet at the headrace end to 22 feet at the other; they are 28 feet deep at the lower end. Each pit has four draft tubes for the six wheels mounted on one shaft, and the tubes discharge into the arched openings of the tail pits, passing under the power house to the tail-race. Across the entrance to each pit are the racks to exclude any ice or drift that may pass through the submerged openings, and behind these are folding gates, which can be closed to shut off the water and allow access to the wheels. Any water leaking through these doors is taken care of by a 16-inch cast iron drain pipe imbedded in the concrete and discharging into the first draft tube. The work was designed by Albert S. Crane, Hydraulic Engineer.

CONSTRUCTION WORK.

The excavations for the wheel pits and for the foundations of the dam and power house are in the Joliet limestone. This is fairly solid, but contains a number of springs which required special attention, and also developed some deep clay pockets running (as on other parts of the canal) from southwest to northeast. The pockets are from 2 feet to 10 feet wide and consist of a stiff blue shaly clay, which gradually softens when exposed to air and water. In order to prevent the possible blowing out of the clay under the walls



Two Piece Concrete Block Construction

in the future, when softened by long exposure, concrete cut-off walls are carried down 15 or 20 feet into the clay, and where the surface of the clay is exposed it is excavated and covered with a floor of concrete.

The power house is formed as an integral part of the dam and has concrete foundations on the solid rock. The wheel pits are also excavated in the rock and were outlined by a Sullivan channeling machine before any blasting was done, so as not to disturb the rock of the piers or abutments between the pits.

A careful record was kept of the square feet channeled by the machine used on the wheel pit excavations. The best record made at one time was 382 feet in 12 hours. The total cutting in 40 consecutive shifts of 10 hours each during June, 1905, was 8,120 feet or 203 feet per shift. The machine frequently worked 24 hours a day and seven days a week, but was run continuously through the entire summer and fall without repairs. In comparison with these records it may be interesting to note the performance of 15 of the 55 Sullivan channelers used in the construction of the main channel of the Chicago Drainage Canal, as indicating the improvement that has been made in the manufacture of these machines in the last 12 years. During May, 1895, on that work the 15 machines referred to, averaged 116.2 feet each per shift, as compared with the record of 203 feet per machine per shift on the present work. The construction conditions on both pieces of work were practically the same, and in all cases delays of all kinds are taken into account.

The pits are all faced with concrete about 36 in. thick, worked with spades to give a smooth surface finish. The dump cars, filled by a steam shovel in the bottom of the excavation, were hauled out on a cable incline at one side and taken in trains to the dumps behind the retaining walls or to the crushing plants for the concrete work on these walls. The stone for the concrete of the power house was loaded into the bucket of a cableway 400 ft. long, and delivered either directly to the stone bin, or to cars running to this bin. This cableway was placed

The Cofferdam, Lower Tail Race

parallel with the line of the canal, and was moved laterally to serve the work at the different pits. Steam for the channeler, drills, hoist, cableway and concrete mixer was generated at a central boiler house, containing two boilers of 100 horse power capacity each, and distributed by pipes, the greatest distance from boiler to work being about 400 feet. The cut on page 16 shows the channeler in the bottom of the pit, and the cableway above it with the crusher and stone pile in the background and the concrete retaining wall of the forebay at the left. The cut on page 17 shows two of the pits, with the forms for the concrete lining and also the forms for the draft-tube opening.

POWER HOUSE OF CONCRETE BLOCKS.

This building is notable in that concrete block construction was adopted for both plain and ornamental work. As already noted, the power house and dam form practically one structure. The north wall, which is the dam proper, is of concrete; the south and end walls will be of concrete blocks. The roof will have steel trusses, with plank sheathing covered with asphaltum felt, and red tile. The walls, built of blocks, are 37 in. thick at the base and at pilasters and 28 in. at the top and between pilasters, and are composed of T-shaped blocks, illustrated on page 18. The ordinary blocks are machine molded, but the blocks for the ornamental work, cornice, reveals, etc., the voussoirs for the window arches, and the large blocks for lintels, sills, pilasters etc., are tamped by hand. The large blocks are also reinforced by plain round steel rods. The color is a light gray and the face is of a close and even texture. A

Sullivan Straight Line Air Compressors at the Golden Cycle Mine, Independence, Colorado (See page 23)

water proofing mixture is used to face the blocks forming the exterior walls.

A 50-ton electric traveling crane will provide for the handling of heavy machinery in the power house.

TURBINES AND GENERATORS.

The power house is arranged for eight units in two groups of four, separated by three exciter units. The present contract, however, is for four power units and two exciter units. Each of the 6,500 horse power units will have six wheels, mounted on a 12-inch horizontal shaft, the shaft projecting through stuffing boxes in a steel bulkhead wall into the generator room and being coupled to the shaft of a revolving field, 60-cycle, three-phase generator. The normal head, as measured between the level of water in the turbine chamber and the tail race when all the wheels are running, is 34 ft. but under operating conditions the head may vary from 30 to 38 ft. The turbines are of the Jolly-McCormick type, and the contract also includes two 600 horse power turbines for the exciters, with Lombard water wheel governors and the necessary gate opening mechanism. The specifications required for each power unit a discharge of 100,000 cubic feet per minute, with 0.8 gate opening, the power not to be less than 5,000 horse power at such opening and the speed not less than 165 revolutions. The efficiency of the turbines must be at least 80 per cent. from 0.75 to full gate when running

g the required speeds the same good being maintained from 0.75 to full gate

The four generators will be of the revolving field type [illegible] K W [illegible] gates, three phase [illegible] cycles and running at [illegible] per minute [illegible] of the two units will be a [illegible] K W [illegible] unit [illegible] direct connected [illegible] exciter generator running at [illegible] revolutions per minute and having a shaft with [illegible] and self cooling [illegible]

TRANSMISSION LINE

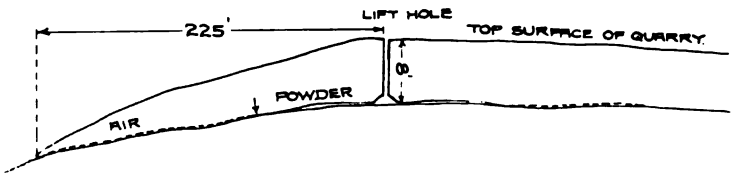
The length of the high tension transmission line to Chicago will be about 30 miles and it will be built on a private right of way from 50 to 75 ft in width The poles will be spaced about 150 ft apart, and will have two cross arms 10 ft 6 in and 12 ft long with locked three pin insulators There will be four wires on the lower arm and two on the upper arm the bottom wires being 40 ft above the ground There will be two circuits and aluminum wires are to be used equivalent to copper [illegible] No [illegible] gauge The current will be generated at 6 600 volts and the power house stepped up to 66 000 volts for transmission and distributed from the Chicago substation at 2 300 volts [illegible] Mr H H Eldredge is electrical engineer

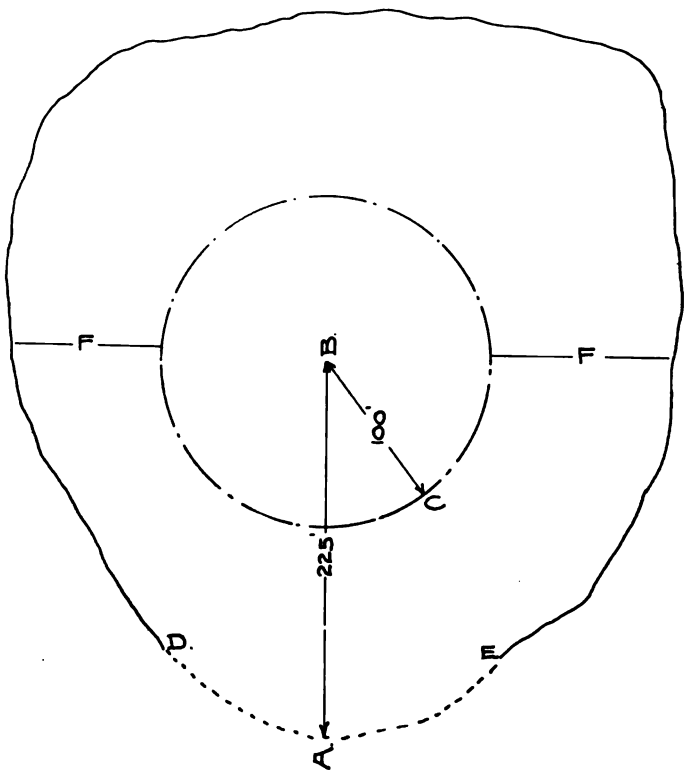
TUNNELS

The tailrace was excavated partly in rock by the use of channelers and drills as above described in connection with the headrace. (See page 18) The lower portion, however, runs in the bed of the Des Plaines river, which is 150 ft wide at this point A timber dam nearly [illegible] in length was erected, [illegible] at the half of the river bed here The bed was then excavated to the depth of 10 ft at the upper end to 30 ft at the lower Two or three feet of earth was first removed by the contractor and solid rock was then excavated by rock drills and steam shovels Difficulties were presented by the constant leaking of the cofferdam due to the irregularity of the bottom of the river caused by the [illegible] at this point of the Sanitary District

The contractors for the head race and for that portion of the tail race requiring [illegible] are J J Duffy & Co of Chicago [illegible] and final letting of [illegible] of the contract for the remainder of the tail race, and [illegible] Bros Co of Janesville Wisconsin are constructing the power house

Mr Isham Randolph member Amer. Soc. Civil Engineers is chief engineer in charge of the work We are indebted to Mr Geo M Wisner assistant chief engineer for drawings and information also to Mr Edward L Bates inspecting engineer of the power house section and to the contractors on this portion of the work for photographs Articles regarding the details of this work have appeared in the Engineer





KEY—

B—Lift or Drill Hole.

BC—Area Cleaved by Powder.

AFF—Area Cleaved by Compressed Air.

DE—Thin Edge on down hill side of quarry, where air escaped.

ing News of January 12th, 1905, January 18th, 1906, and the Engineering Record of February 17, 1906, from which we have quoted to some extent in the present article.

LOW COST OF COMPRESSING AIR FOR DRILLS.

(From the Cripple Creek Daily Times)

An interesting feature of mining in the Cripple Creek district, and an item which is as closely watched by the operator as any other, is the cost of making air per drill shift, upon which largely depends the possibilities of economical operation. The wide range in this one respect is shown by the fact that in some instances the cost is as high as $3 per drill shift, while in others the same results are obtained at a cost of 53 cents. This great difference is due to the class of machinery used and the care and intelligence with which it is operated. Of the different records obtained from mine operators the following seems to show the greatest economy:

Mr. John Sharp, the well known lessee who is operating the Morning Glory of the Work and the Colorado Boss of the Cripple Creek Consolidated company furnished data covering a period from September 20, 1904, to January 17, 1905, during which time 1,367 drill shifts were operated. As shown by his books, during that time, the coal bills amounted to $1,183.17. The greatest number of shifts worked in one month was in October, when 492 were employed.

The rock hoisted amounted to 7,500 tons during the months of October, November and December, and the coal bills for hoisting amounted to $450, leaving the total coal bill for running the air compressor $733.17 or 53.7 cents per drill shift.

It is doubted if this record can be duplicated in the district. In speaking of his accomplishment in economical operation Mr. Sharp said: "I think that my record for making air per drill shift is about as low as it can be made. My cost was 53.7 cents per drill shift for coal. The machine used was a straight-line compressor with simple steam and compound air cylinders, and was built by the Sullivan Machinery company of Chicago. It is supposed to operate only ten drills, but often exceeded the rated capacity. In my opinion it is as economical a compressor as can be constructed and certainly the tests I gave the machine under all conditions, are sufficient to demonstrate this fact."

CLEAVING GRANITE BY COMPRESSED AIR.

Necessity is the mother of invention in the stone quarrying business as in other branches of human activity, and the inventions and circumventions of quarrymen are many and varied. One of these, which we believe has not come to general notice, is the use of compressed air for splitting granite, to create working beds as practised by the North Carolina Granite Corporation, at Mt. Airy, N. C.

The company's property covers a gently sloping hill-side of many acres, consisting of a perfectly solid, homogeneous mass of moderately hard granite. This stone shows no ledges or bed planes whatever, but splits readily in a straight line in almost any direction. In order to make quarrying economical, this feature is taken advantage of to create

A Corner in the North Carolina Granite Corporation's Quarry

artificial beds to which to work. Large sheets or laminations of granite are separated from the mass at a single operation in like manner as an onion is peeled, by the successive use of powder and compressed air. The stone is then split up into proper sizes for building stone, paving blocks, curbing, lintels, and stock for monumental purposes, at very low cost.

In the center of the sheet or area to be lifted, a drill hole two or three inches in diameter is sunk six or eight feet in depth, depending on the greatest thickness of stone required. The bottom of the hole is enlarged into a pocket by exploding half a stick of dynamite, as indicated in the sectional sketch shown on page 22. A small charge of powder, about a handful, is then exploded in the pocket, thus starting a horizontal crack or cleavage across its greater diameter. Charges increasing in size are now exploded in the cavity, the drill hole being plugged at each blast, to confine the powder gases and thus exert a more or less constant force upon the stone.

After the cleavage has extended to a radius of 75 or 100 feet in all directions from the lift hole, a pipe is cemented into the hole and connected by means of a globe valve, to the air pipe line from an air compressor. Compressed air at 70 to 80 pounds pressure is gradually ad-

Power House, Cutting Sheds and Offices

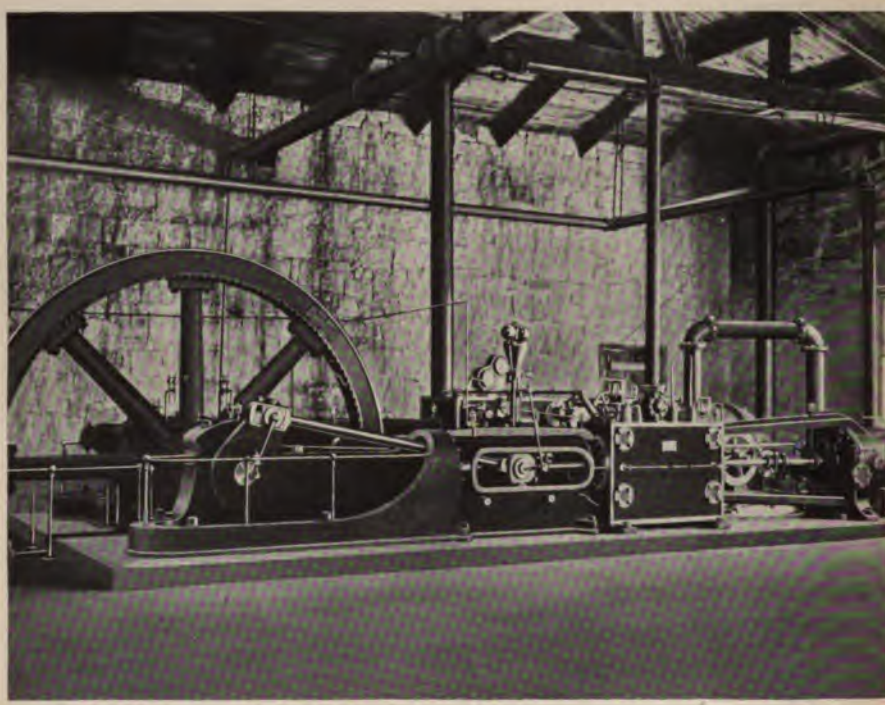
method and the cleavage rapidly extended until it comes out upon the hillside in a thin edge, as indicated by the cross sectional sketch referred to above. A sheet of several acres in extent may be raised in this manner, affording a bed plane approximately horizontal, to which the quarry-

Thin edge of sheet split from quarry

men can work, thus securing stone of any required thickness.

This method was not perfected in a day, but represents a gradual development. For a number of years, the company has followed the practice of quarries in the Lithonia and Stone Mountain districts of Georgia, in splitting ledges in the above manner by the use of powder alone. This system, however, was not entirely satisfactory, as the amount of powder used was necessarily considerable, and the time required for raising such a large area of granite was quite long, as unless considerable care is taken and time afforded for the stone to split gradually with the aid of natural expansion and contraction, the force of the explosion brings the cleavage abruptly to the surface.

Some time ago the North Carolina Granite Corporation substituted water under pressure for powder, after the cleavage had extended some little distance from the drill hole. This was found to be an improvement, but was surpassed in economy and convenience by compressed air when the company installed a new Sullivan air compres-



The Sullivan Corliss Two Stage Air Compressor

or, especially built for this plant, last season.

When the compressed air was first tried, a pressure of 80 pounds was admitted into the cavity, which had previously been extended to a distance of 100 feet from the lift hole. The power of the air was too great for the easily splitting stone, and the cleavage turned abruptly to the surface. A new drill hole was sunk in another part of the quarry, and the cleavage extended by powder in the same manner as before. The compressed air pipe was then attached once more and air admitted very gradually. The stone could soon be heard cracking in all directions, and in about half an hour the cleavage came to the surface in a thin edge on the hillside, some 225 feet from the lift hole. (See cut on page 25). The time required for extending the cleavage by powder for 100 feet was between two and three weeks, while to split the larger area, between 100 and 225 feet radius, required only half an hour when compressed air was used.

The accompanying sketch (page 22), shows how the area, covering nearly 2½ acres, was raised by this means. Only a portion of the cleavage extended to the surface, owing to the thickness of the ledge on the up-hill portion of the area. The bed plane thus formed was reached at these points by quarry bars and drills in the usual manner. So far

Interior of Cutting Shed

as known this is the only quarry in which compressed air is used to split granite in this manner, and it can readily be understood that this process accomplishes a great saving of time and expense.

The North Carolina Granite Corporation is enabled by this and other economical methods of operation, to produce granite for many building and paving purposes at a price comparing favorably with any quarry in the country. Its equipment is modern in every respect, and includes 35 plug drills, three Sullivan tripod drills, four Sullivan quarry bars, 15 surfacing machines and 60 small hand tools. These are all operated by air power from a Sullivan Corliss air compressor, furnished by the Sullivan Machinery Co., of Chicago. (See page 26). This compressor is of the two stage type, with a piston displacement of 2,000 cubic feet of free air per minute at 78 r. p. m., against 80 to 100 pounds terminal pressure.

The dimensions of this compressor are as follows: steam cylinders, 16 and 28 in. by 42 in. stroke; air cylinders, 26 and 16 in. by 42 in. stroke.

The steam end is a Sullivan heavy duty Corliss cross-compound condensing engine, to the rear of which the air cylinders are coupled in tandem. All cylinders, both steam and air, are made with separate liners, forced into the cylinder castings by hydraulic pressure. A steam receiver and reheater is situated between the high and low pressure steam cylinders, below the floor line. Air efficiency in this machine is rendered unusually high by the valve motion employed, which consists of Corliss inlet valves upon both air cylinders, and automatic poppet discharge valves situated in the cylinder heads. These valves, together with their seats, are readily removable for inspection or regrinding. The air supply is drawn from outside the engine room, thus insuring cold, clean dry air, and the

air cylinders and cylinder heads are water jacketed. The heat of compression is further removed by a large receiver intercooler between the high and low pressure air cylinders.

The general view of the quarry, (page 24) shows one of the nine cableways by which the stock is handled between the quarry and the cutting shed and cars. There is also an incline for loading rough stock for shipment. The engine room, offices and cutting and finishing sheds are of modern design. The boiler and engine house is 112x53 feet and contains two 210 H. P. water tube boilers, a 150 H. P. Ideal compound engine coupled direct to a 100 k. w. generator, and the air compressor above described. The cutting shed is 360x65 feet in size. Stock is handled by a 20-ton Pawling & Harnischfeger electric crane, with a 5-ton auxiliary hoist.

The company has made ample provision for further enlargement of its equipment, to care for its rapidly growing business.

MINE AND QUARRY is indebted to Mr. Thomas Woodroffe, vice president of the company, for photographs and information used in this article.

SUGGESTIONS FOR OPERATION OF ROCK DRILLS.

When drilling in sandstone the drill-bit should be tapered somewhat and then flattened instead of drawn to a cutting edge. If a chisel-bit is used in drilling sandstone, the bit will wear very sharp, and will frequently become fitchered.

In forging rock-drill bits, those for medium hard rock should have sharp chisel bits. As the hardness of the rock increases, the angle of the bit may be made more blunt, and the cutting edge shaped from a straight line to a curve, to prevent the corners being chipped off.

Never rush a missed hole—give it plenty of time, and all night is not too long sometimes. The missed hole is one of the greatest menaces to the miner. When safe to examine the hole, carefully withdraw the tamping down to the powder, insert another primer, and after retamping the hole, fire it again. Should it go, the chances are in favor of all the powder in the hole being exploded.

—From the Mining and Scientific Press.

A rock drill pipe line which has been choked by freezing, may be cleared almost instantly by turning a very small amount of wood alcohol into the line. It will hardly prevent frost from reforming, except for a short time, but is of great aid in cleaning out frost already formed.

Cutting of rock drill cylinders is often due to lack of proper lubrication. When a new drill is started up, a lubricant consisting of one pint of cylinder oil to one-fourth pound of flake graphite should be used, one tablespoonful of lubricant for each five-foot hole drilled, during the first ten or twelve shifts. After this, use a good grade of drill oil, one spoonful for each ten-foot hole drilled.

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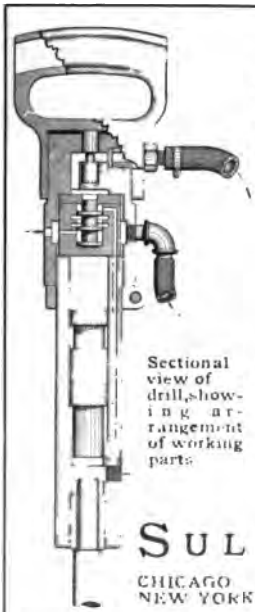

Sectional view of drill, showing arrangement of working parts

A NEW PLUG DRILL

OF HIGHEST SPEED AND DURABILITY

The new Sullivan Plug Drill, here shown, has drilled 160 $\frac{5}{8}$" x 3" holes in one hour in Barre, Vt., granite. Will drill holes to 12-inch depth. Weight, 20 lbs.; air capacity, 14 ft. per minute.

Sent anywhere on 15 days' trial, at our expense, if not satisfactory

BULLETIN 51-C

SULLIVAN MACHINERY CO.

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MINE AND QUARRY

THE UPPER PORTAL OF THE GUNNISON TUNNEL, MONTROSE COUNTY, COLORADO

The Gunnison Irrigation Tunnel

Quarrying Sandstone at Amherst, Ohio

Drilling in Colliery Development

SULLIVAN MACHINERY CO.

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THE GUNNISON TUNNEL OF THE UNCOMPAHGRE IRRIGATION PROJECT

Written for Mine and Quarry by M. G. Doll.*

It is only by close acquaintance with some specific undertaking such as the one described in this article, that it is possible to realize the extent of the work being done by the U. S. Reclamation Service. The Uncompahgre project is but one of dozens of irrigation systems which are being developed throughout the West. Some of these are larger in extent and more important in their results than this, but from an engineering standpoint, none is of greater interest. The driving of a tunnel nearly six miles in length through materials ranging from soft mud to hard rock is a large enterprise, particularly when it is remembered that owing to the height of the hill penetrated, nearly five miles of the tunnel are being driven from two headings, one at each end, without intermediate shafts for ventilation and removal of excavated materials. This tunnel is the longest, although not the largest in point of diameter, in the United States, and as far as the writer's information goes, it is the longest in the world, driven as above described from only two openings and without intermediate shafts. The methods and the progress made, as described below, reflect great credit upon the skill and executive ability of the government engineering force in charge of the construction.

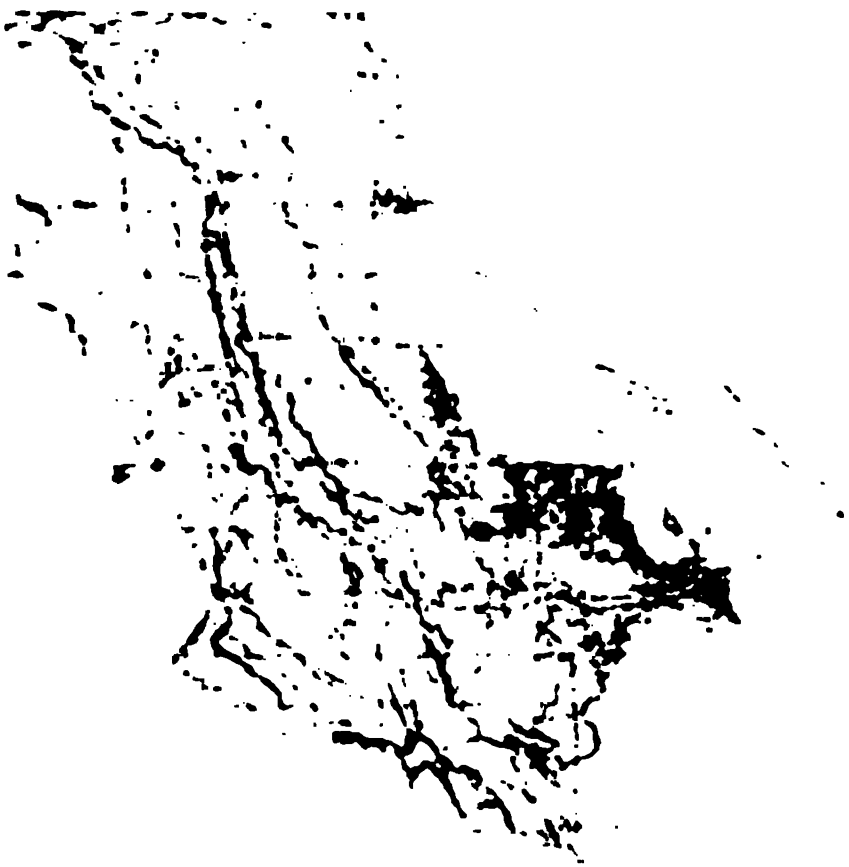
THE IRRIGATION PROJECT.

The Gunnison Tunnel is part of the Uncompahgre Valley Irrigation Project, undertaken by the United States Reclamation Service. This project when completed will reclaim about 150,000 acres of land, in the Valley of the Uncompahgre river, in a portion of Montrose and Delta counties, in the west central part of Colorado. (See general map.) Small portions of the Uncompahgre Valley have been under irrigation for some time, by water drawn from the Uncompahgre river, but owing to the limited supply of this water, the irrigation necessarily had to be restricted to a small area. However, these preliminary experiments served to show the possibilities of this land, if it could be supplied with a sufficient amount of water.

The soil in the Uncompahgre Valley is practically of two kinds, an adobe on one side and a sandy soil on the other. The adobe has proven to be adapted especially to wheat and other small grains, in general, while the sandy soil is more strictly adapted to fruits, potatoes and sugar beets. The productive season of this section has been in the past rather long, spring opening early and the autumn frosts coming late. These facts, coupled with the large choice of crops, should not only make the project a thorough success, but they should also make this one of the ideal sections of the state for homesteads.

To accomplish this condition of affairs it was calculated that an additional water supply of 1,300 cubic feet per second, during the productive season, would be necessary. Records of the Gunnison river showed that an average maximum flow of 14,200 cubic feet per second occurred in June and a minimum of 750 cubic feet per second in September; during April of this year there was an average flow of 1,481 cubic feet per second. The Gunnison river, therefore, carried sufficient water to furnish the necessary supply for the Uncompahgre Valley project, but it was locked in one of the characteristic cañons of Colorado, with nearly perpendicular walls of solid rock about 1,500 feet in height. After a thorough investigation on the part of the Reclamation Service, it was finally considered feasible to divert the water from the Gunnison cañon by running a tunnel

*1748 Broadway, Denver, Colo.



Town of River Portal and the Gunnison River; the small cross on the left bank indicates the east portal of the tunnel.

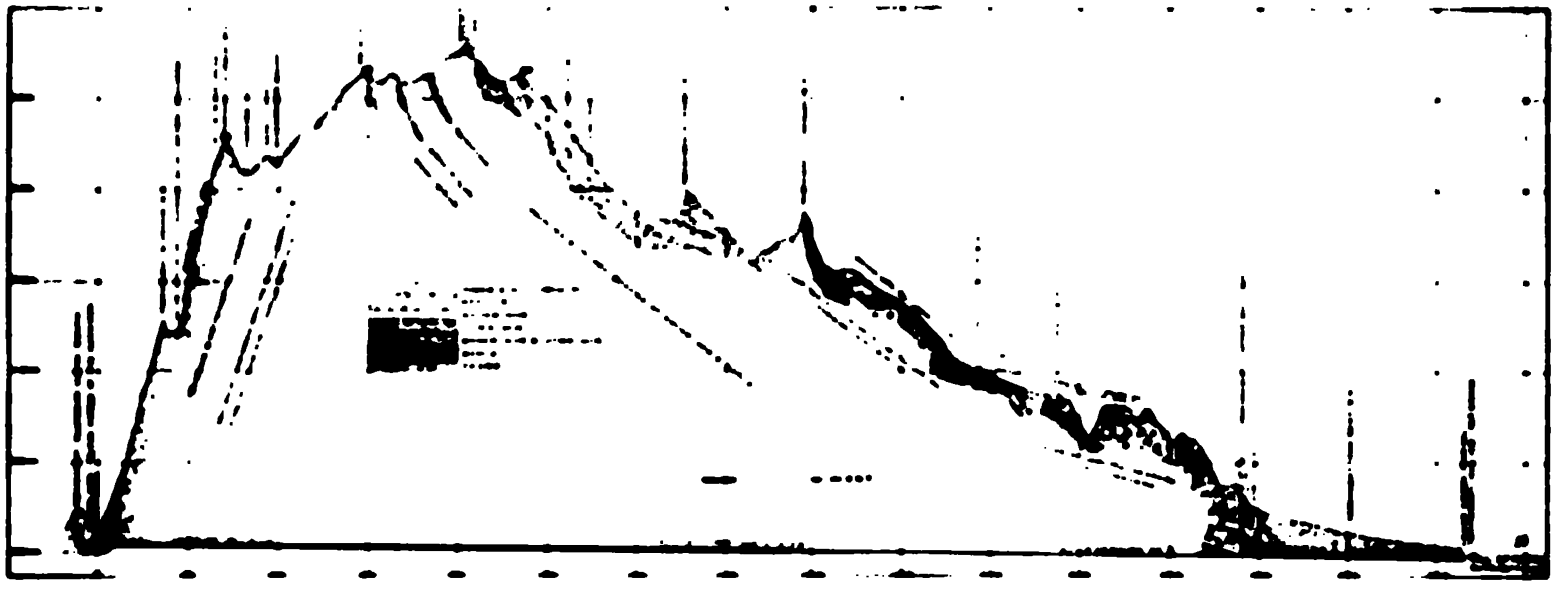
Montrose county, altitude (grade line of the tunnel at Section No. 1) 6,533 feet. (See general and profile maps.) The grade line of the tunnel is about six feet below the lowest point of the bed of the river. At the present writing, the plans and specifications for the controlling gates have not been passed upon. The total length of the tunnel from the east to the west portal will be 30,582 feet, with a fall of 2.02 feet per 1,000 from the east to the west portal. It is designed to have a capacity of 1,300 cubic feet of water per second with a velocity of 12.6 feet per second.

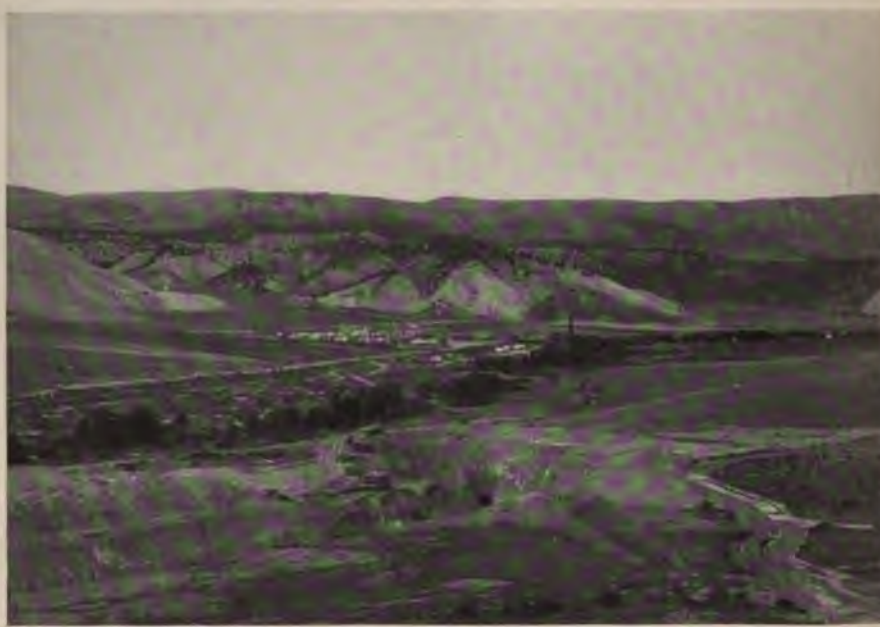
The tunnel is ten feet in width at grade, with walls slightly sloping to the base of the arched roof or invert, where it is 11 feet wide. The height from the floor to the highest point varies from 11 feet five inches to 12 feet. The greatest depth from the surface of Vernal Mesa to the tunnel is 2,200 feet. The accompanying profile map and cross section of the tunnel at different points indicate the extent and character of the undertaking.

The postoffice name of the camp at the east portal is River Portal; that at the west end of the tunnel is Lujane. They are connected by a government road about 12 miles long, passing over Vernal Mesa. This road and a general view of the Mesa are shown in the photograph on page 36. The building of this road was an engineering feat in itself, especially on the River Portal side, where the walls of the cañon are extremely steep and rugged, the summit being nearly 2,000 feet above the river.

THE DISTRIBUTING CANALS.

From the West Portal, 1,250 second-feet of the water will be carried through a cement-lined canal (50 second-feet having been diverted to Cedar creek near the portal) to the Uncompahgre river, where a number of branches are made, the bed of the Uncompahgre river also





The West Portal and Town of Lujane.

being utilized to convey a portion of the water. As the grade from the West Portal to the Valley is quite steep, it will be necessary to lower the water by gradual stages, so that the walls and bed of the canal may not be destroyed by the velocity of the flow. This fall is accomplished by a series of 14 steps, which are so placed as to cause the water to fall on a grating of eighty pound steel rails, spaced eight inches apart, the rails being held in place by a double concrete arch. This grating serves to break the force of the fall and also to catch any debris which may be carried down the canal. From this grating the water falls into a basin of sufficient depth to form a water cushion, thus preventing any damage to the concrete lining.

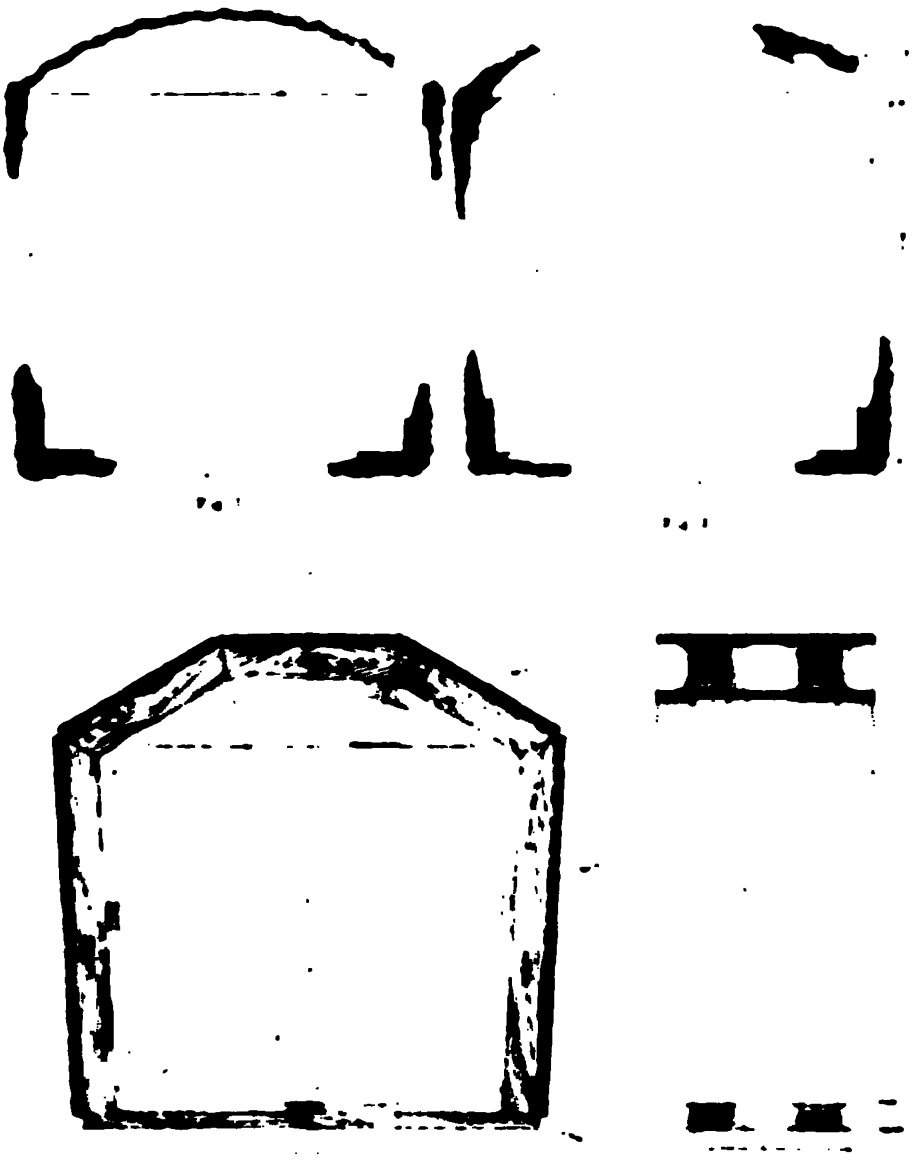
TUNNEL CONSTRUCTION—MATERIALS ENCOUNTERED.

The main tunnel was driven from four separate headings (see profile map), No. 1 at the east portal, Nos. 2 and 3 from a two hundred-foot shaft which was sunk about a mile from the west portal, and No. 4 from the west portal of the tunnel. Nos. 3 and 4 have since met, thus leaving work at Nos. 1 and 2 in active operation at the present time. Heading No. 1 was driven in a hard rock formation from the beginning, while the materials in Nos. 2, 3 and 4 vary from a soft adobe mud in No. 4 to a very soft, extremely brittle shale in No. 2. The ground in No. 4 and the latter part of No. 3 just previous to the junction of Nos. 4 and 3 consisted of a soft swelling adobe mud.

The sections of the tunnel running through the mud and soft shale were timbered with eight and twelve inch pine timbers, and the whole tunnel section is lined with concrete as shown in the cross section sketches.

METHODS IN EARTH AND SOFT ROCK SECTIONS.

Heading No. 2 and the first part of No. 3, in soft shale, were advanced by a



TYPICAL SECTIONS OF TUNNEL LININGS FROM

The road over Vernal Mesa.

bench and overcut heading system, employing air-driven rotary drills or coal augers. With a few exceptions, where the ground was firmer than ordinary, the timbers were advanced by the crown bar system, which consisted in carrying the roof on temporary stringers held in place by jack-bars, until the permanent timbering could be finished. Very rapid work was accomplished in this ground, in a few cases over 600 lineal feet being driven during one month.

The muck from headings Nos. 2 and 3 was hoisted through the shaft, located at their starting point, while that from No. 4 was hauled in side dump tunnel cars, holding 1¼ cu. yds. each, through the west portal and run out on a dump at the side of the main canal. In heading No. 2 the tunnel has recently passed through a deposit of sea shells, some of which were three and four feet in diameter. These shells sometimes fell without warning, bringing down masses of shale from the roof of the tunnel.

During the latter part of July of this year, the hoist originally used for headings Nos. 2 and 3 was put out of commission, and the muck from No. 2 heading is now being carried through the west portal of the tunnel. This is a very economical operation, as the loaded cars are carried on the down grade, therefore the amount of muck moved by the mine locomotives depends largely on the number of empty cars the locomotive is able to haul up the grade. At the foot of the shaft a large room has been constructed. It is intended to install one of the concrete plants in this room, and divide the shaft into two compartments, to be utilized for supplying by gravity feed the gravel and sand used in the concrete. A very good grade of these materials is obtained from the Mesa in the near vicinity. The concreting will be simultaneously begun in a number of places in the west portion of the tunnel, as soon as the mixing machinery can be installed.

EAST PORTAL—ROCK CONSTRUCTION.

In heading No. 1 (driven from the east portal) a different condition of affairs exists. This heading has been in very hard rock ever since the beginning of operations, and from all indications it will probably continue so until headings Nos. 1 and 2 meet.

Owing to the fact that the grade line of the east portal is six feet below the bed of the river, it was necessary to make an opening above the high-water mark of the river, and then drop sharply to the grade line. This causes a short, steep incline, at the mouth of the tunnel, which necessitates the use of a small hoist, for hoisting and lowering the electric locomotive and the two-yard loaded muck cars. These cars are handled on the dump by a stiff leg derrick designed and built on the ground by the government engineers. (See cut, page 40.)

View from top of shaft for headings 2 and 3.

The East or River Portal; to the left is the hoist house.

The rock work at the east portal was begun by contract. Under the supervision of the contractors the work was advanced by an undercutting drift, the roof being subsequently shot down. Owing to this method, and to deficiencies in equipment, as will be shown below, progress was unsatisfactory and the contractors abandoned their task. The work was then taken up by the United States Reclamation Service, and overcut heading and bench work was installed. Since this time the work has been making very satisfactory progress.

As mentioned above, the height of the hill over the tunnel prevents the sinking of a shaft for ventilation and removal of materials. Ventilation is provided by means of powerful blowers at either end of the tunnel, and no trouble has been experienced on this score. All materials excavated are removed through the tunnel itself. The method employed in the west heading has already been described. From the river heading the muck cars are run to the bench on a double track, the forward cars being filled by the bench muckers and the after cars by the heading muckers. The muck from the heading is carried to the rear cars on wheelbarrows, over the bench and onto a gang plank, supported above the cars on long mining bars. This method of driving a tunnel has shown its merits and proven its practicability to its more rapid advance and to lower cost of operation, as demonstrated by complete records of these details for both systems, kept by the engineering force.

ROCK DRILLING.

The original contractors had installed a Leyner air plant with Water Leyner drills, and the use of this plant was continued under the new system. Four Leyner drills were used in the heading and two on the bench. In February of this year, Mr. W. H. Davis, a tunnel man of experience, was appointed superin-

Sullivan Rock Drills in Heading No. 1 of the Gunnison Tunnel; Superintendent Davis is in the foreground.

[illegible] Shortly before 4 p.m. on September standard three inch [illegible] were exhausted in the Lower [illegible] The change produced a marked increase in the progress of the miners as well as a considerable saving in the cost of the repairs over the night the work became [illegible] much drier repairs in the Lower drills for a period of [illegible] months, from September 1st 1911, to March 1st 1912, with the exception of [illegible] three months from April 1st 1911, to 1st July. [illegible] were employed for the repair party, and for the drills in the [illegible]

TABLE No. 1

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]										
[illegible]										
Cunningham Formation	Surface [illegible]	Hard [illegible] Bedrock Mine	Hard [illegible] Bedrock Mine	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* The [illegible] was kept at the [illegible] and [illegible] was [illegible] during each shift for the amount of water [illegible] [illegible] was [illegible] as much as [illegible] behind the face of the [illegible]

TABLE No. 2

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cunningham Formation	Fine to [illegible] [illegible] [illegible] [illegible]	Hard Blue Bedrock	[illegible]	[illegible]	[illegible]	[illegible]

* [illegible] drills [illegible] about the middle of [illegible]

[illegible] It was also found that [illegible] between drills in the heading [illegible] in the bench, were [illegible] and by unsuccessful [illegible] in the work. The following tables, compiled from the records kept by the government engineers, will give an idea of the progress made [illegible]

The following results were [illegible] from a special report on the engineers [illegible] comparing the relative [illegible] [illegible] with the [illegible] [illegible] [illegible] [illegible]

average cost of repairs, steel and labor for one Sullivan drill per month to be approximately 29 per cent of the cost of repairs for one Leyner drill per month.

POWER PLANTS AND EQUIPMENT.

The power plants at Lujane and River Portal are constantly changing as the work advances. The former has a tendency to decrease in extent, owing to the smaller number of headings being supplied with power, and to the fact that the grade of the tunnel is toward the west portal. The plant at River Portal, conversely, has a tendency to increase. At the present writing the Lujane plant proper comprises three electric generators rated at 275 kw., which operate three high speed engines; two straight line and one cross compound steam driven compressors with a total capacity of 1,600 cubic feet of free air per minute, and boilers of 500 H. P. capacity. In this end of the tunnel are installed suitable pumps, a 75 H. P. air hoist, two 25 H. P. blowers, and three electric mine locomotives, with a large number of 1¼ yard dump cars. A number of air-driven coal augers are also in use.

At River Portal the plant comprises the following machinery: One 1,000-foot straight line compressor, and one cross compound, two-stage compressor with a capacity of 600 cubic feet of free air per minute. The air pressure used throughout the tunnel is 100 pounds. Two 100

Derrick for dumping cars, River Portal.

The power plant at River Portal and a group of engineers; from left to right: Messrs. Daniels, McDermitt and Lytle.

H. P. engines are driven each by a 75 k. w. 250 volt D. C. generator, and one 55 H. P. engine is driven by a 45 kw. D. C. generator. Steam power is supplied by three 80 H. P. horizontal tubular high pressure boilers, and one 100 H. P. boiler. A suitable equipment of pumps and condensers is installed. In the east tunnel there are in use, two electric mine locomotives, an adequate number of dump cars, one 50 H. P. hoist with a 3 ft. 6 in. clutch-driven drum, and a blower with a capacity of 5,000 cubic feet of air per minute, which is used for ventilating purposes, the air passing through an 18-inch sheet iron ventilator pipe. Eight Sullivan class UD drills are also in use in this heading, five of which are used in driving the tunnel and three kept in reserve. Thirty-pound rails are used for the tunnel track, and the entire length of the tunnel is lighted with 16-candle-power electric lamps, with arc lights in the headings.

LABOR AND LABOR CONDITIONS.

The camps at River Portal and Lujane are notably well equipped and well built, both from a sanitary point of view and for the comfort and entertainment of the employes. There are a few tent houses, but most houses are boarded, and both the sides and roofs are covered with roofing paper, which makes a house warm in

winter and comparatively cool in summer.

Each camp is equipped with a small but complete hospital in charge of a competent force of trained nurses. All houses are lighted with electricity and connected with a town water supply. A well-organized commissary is operated by the government, also a large boarding house, provided with a large, roomy, well-ventilated sanitary kitchen, where the unmarried men are given board. Besides all those necessaries of life, the Government also provides a large, well-lighted and ventilated reading room, a town hall where entertainments, dances and concerts may be held, and also a billiard room. The streets are kept thoroughly clean, and quite a number of the family houses have small grass plots and flower gardens in their door yards.

The writer wishes to express his obligations to Mr. I. W. McConnell, the constructing engineer in charge, for the courtesy and assistance rendered in obtaining the necessary data for this article, also for the favors extended by members of his engineering staff.

The Black Cañon of the Gunnison

CHANNELING IN NEW YORK CITY

By Joseph H. Brown, Jr.

A problem which has long vexed engineers and contractors of New York City in excavating for new buildings, railway cuts, etc., is that of removing rock without disturbing adjacent foundations. To accomplish this by cutting the side walls with track channelers, has up to the present time been declared impracticable, but the success of the Sullivan channelers on the New York Central cut under Depew Place, has conclusively proved the practicability and superiority of this method.

The construction of the depressed yards for the new terminal of the New York Central & H. R. R. Co., at 42nd St., by Butler Bros.-Hoff Co., the contractors, involves the excavation of Depew Place for its full width of 50 feet between 42nd and 44th Sts., a distance of about 500 feet. Below the natural soil and fill, which extends to a depth of from 15 to 25 feet, is the ordinary gneiss rock, which slopes downward to the west at an angle of about 30 degrees, though in some places the top is apparently level. The surface is uneven and the stratification broken and irregular. The average depth of rock to be excavated is about 15 feet, and the total amount, approximately 18,000 cubic yards. On one side of the street, the baggage room extends the full length of Depew Place, and upon the opposite side, is the Grand Central Palace, 200 feet in length.

On account of the proximity of the foundations of these buildings to the line of the cut, the contractors found it impossible to blast without first freeing the rock at the side. This left them the option of making these wall cuts by drilling and broaching or by channeling. After figuring over the costs and estimating the rapidity of the two methods, they

The Channeler on the second lift.

decided to adopt Sullivan stone channelers, and installed a class Y machine with eight-inch cylinder, operated by compressed air, and fitted with an air reheater. The steel used is the solid Z-shaped type. The first cut was started June 30th and since then, the machine has been running almost continuously, 24 hours a day, in three shifts of eight hours each. The cuts have been made in two, and in some places, three lifts, varying from six to nine feet in depth. The illustrations show the channeler at work on the first and second cuts.

The progress made was satisfactory, and about August 1st a second machine of the same type was installed, so that the walls on both sides of the street are being channeled at the same time. These channelers have frequently cut as high as ten feet an hour in the irregular gneiss formation, which is one of the most difficult in which channelers have been used. In figuring the comparative costs of the two methods of cutting rock walls in work of this sort, the following estimate will be of interest:

The cost of drilling and broaching is estimated as follows: Assuming that 60 feet can be drilled per eight-hour shift, six 10-foot holes can be put down; and allowing three inches for the diameter of the hole, and one inch for the rib between, 20 square feet will be *drilled* per eight-hour shift. Furthermore, it will take at least one-half as long to broach as to drill, or one-half shift.

DRILLING COSTS PER SHIFT.

Runner	$3.00
Helper	2.00
Power, oil, blacksmith, etc.,	2.00
	7.00
Broaching	3.50
Total cost per 8-hour shift	10.50

Cost per foot, $.525.

The estimated cost of running a channeler for eight hours is $10.00 including runner, helper, blacksmith and power. Therefore, averaging 60 square feet per eight hour shift, the cost per foot is $.16⅔, a saving of .36 per foot, or .683% over the method of drilling and broaching, in addition to cutting the time in half.

Results have fully approved the judgment of the contractors in the work above described. The channeler has proved its right to be called an important addition to the contractor's equipment, and it has come to stay in New York City work.

In addition to the Sullivan channeling machines, ten Sullivan rock drills are now in use for drilling the blasting holes between the channeled walls.

The photographs reproduced herewith show an interesting feature of this work, namely: the deck and supporting timbers necessary in order to carry on the work without interfering with the street traffic. The work was begun in January last, and the contractors expect to complete the excavation about October of this year.

A NOVEL USE OF DIAMOND DRILLS

"One of the greatest feats in mining engineering in the anthracite region for many years was recently achieved," writes the Scranton (Pa.) correspondent of the *Engineering and Mining Journal*, "when the old Garfield workings of the Henry Clay colliery, of the Philadelphia & Reading Co., were reached by a diamond drill for the purpose of draining the water confined therein. The old openings, which are more than two miles in extent, will now be drained at the rate of 1,500,000 gallons every 24 hours, through an opening of 4 inches in diameter, which was made by the diamond drill. This huge lake was tapped at an angle of 11° and at a pressure of more than 1,000 lbs., so that considerable discretion and nerve had to be exercised."

The accompanying cut shows a Sullivan class "S" drill in the Pancoast Colliery of the Scranton Coal Co., at Throop, Pa. This drill is shown boring a water hole from the Big Vein, 225 feet from the surface, at an angle of 14 degrees up from the horizontal, to tap a large body of water in the upper level. The hole was 320 feet in length. The photograph was taken by the contractors, Sprague & Henwood, of Scranton.

Deviation of diamond drill bore holes seldom occurs when the drill is in the hands of a skillful operator. It is sometimes due to uneven setting of the diamonds in the bit or to excessive clearance of the stones, causing the bit to turn away from the true line.

The *Engineering and Mining Journal* suggests that such bore holes may be brought back to the plumb by forcing an India rubber washer down to a depth of twenty yards or so beyond the point of deviation, and then running in liquid cement to a few feet above where the hole has deflected. The cement is allowed to harden properly, when boring may again be commenced in the right direction.

DRILLING IN COLLIERY DEVELOPMENT

[illegible]

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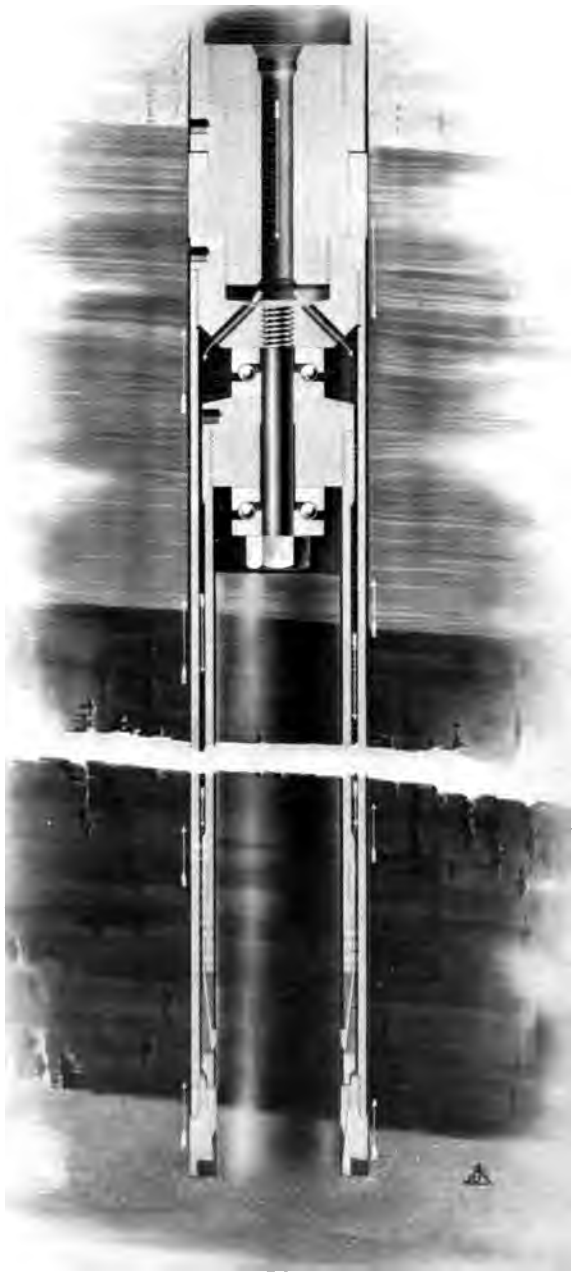


Sullivan Double Tube Core Barrel Passing Through a Coal Vein. The arrows indicate the course of the water.

General View of Ohio Quarries Co.'s Plant.

QUARRYING SANDSTONE AT AMHERST, OHIO

Amherst, Ohio, situated about thirty-two miles west from Cleveland, is the center of the famous Northern Ohio sandstone district. From these quarries is shipped by far the largest amount of sandstone used in this country and Canada, for building, grindstones, street curbing, and similar purposes.

One of the principal producers in this field is the Ohio Quarries Company, whose holdings near Amherst, Ohio, cover a tract of about 400 acres of tested stone land. Here also is located their quarry office.

Two principal openings are at present under operation. These are known as the "Buckeye" and "Amherst" quarries. When the present owners acquired possession, work began immediately at the "Buckeye" quarry, where there is now an opening 800 feet long and 150 feet wide. Stone of the "Split Rock" variety, highly prized in the sandstone field, has been removed at one end to a depth of 168 feet, and there is no indication that the bottom of the deposit has been reached.

The "Amherst" quarry is upon land more recently purchased. Work at this point was inaugurated during the season of 1905.

The product of the "Buckeye" and "Amherst" quarries is grey and buff sandstone of the highest quality. It has been used extensively in public and semi-public buildings in all parts of the country. The Wilkesbarre, Pa., Akron, Ohio, and Vinton, Iowa, court houses are among the larger buildings now being constructed of this stone. The product of these quarries is also worked into sidewalk flagging, street curbing and grindstones. The smaller blocks and irregular pieces are used for small grindstones, reducing waste to a minimum.

The Amherst sandstone lies in horizontal strata, ranging in thickness from eighteen inches to four feet at the surface to from twelve to fourteen feet and over in the deeper beds. It is known locally as expansion or "pressure" stone, owing to the fact that when a channel cut is made through one of the strata, the stone creeps or squeezes, filling the cut. The usual method of opening a quarry by running channel cuts in a rectangle around the entire area stripped, cannot here be employed, since the expansion of the stone would entirely close the cuts. This expansion sometimes amounts to four or five inches. Quarries in this formation, therefore, are opened by cutting two parallel channels about six feet apart, after which cross

channels are run at right angles to the first cuts. When the key blocks at one corner of the quarry are removed a free space is afforded for the expansion of the stone.

At this company's quarries the stone is gotten out by Sullivan Channeling Machines, of the direct acting, single gang "Y" type, driven by steam power, which is furnished by boilers mounted on the machines. These machines are especially built for use in this sandstone, and their valve motion is adjusted to strike a rapid, light blow, giving high capacity without stunning the rock. This feature is of great importance, since if the faces and edges of the channeled blocks were stunned and broken by the jar of the blow, they would require trimming, resulting in waste, expense and delay. Last season a block of stone 40x20 feet, channeled on all four sides, was removed from the Buckeye quarry and split by "plugs and feathers" into eight smaller blocks, each three feet ten inches by three feet ten inches by twenty-two feet in length. These blocks, weighing approximately thirty-three tons each, were turned into pillars for the new Carnegie library now being erected in Pittsburgh, Pa. The channeled edges were found to be as solid as those split by the "plugs and feathers," and showed no signs of fracture or stunning. This feature, together with high cutting capacity, and low cost for repairs and of power per foot of stone channeled, has resulted in the adoption by the company of the Sullivan type exclusively, replacing the double gang, indirect acting type of machine previously in use.

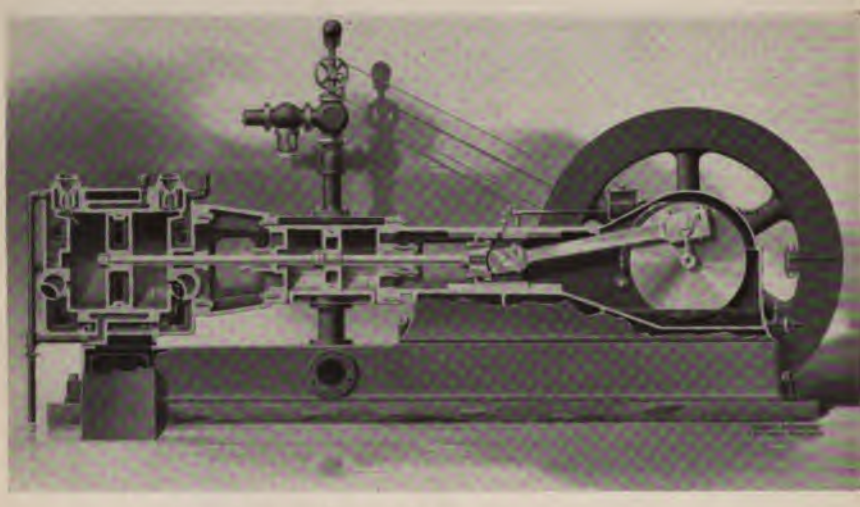
Eight new class "Y" channelers were installed at these quarries last spring, making sixteen machines of this type in

The "Buckeye" Quarry.

The Ohio Quarries Co.—A Sullivan Channeler and Rock Drill.

use at the Amherst quarries of this company. It is interesting to note that the Bedford Quarries Company, a company of mutual interest with the Ohio Quarries Company, employs twenty Sullivan class "Y" machines in its operations near Bedford, Indiana, in quarrying the well known Indiana oolitic limestone. At Amherst the Sullivan channelers cut to an average depth of nine feet. The usual day's run is 225 square feet, although 300 square feet have frequently been cut in a single day. A number of steam rock drills of the Sullivan type, sizes "UC" (2¾ in.) and "UE-11" (3⅛ in. tappet valve) are used for rock excavation and general quarry purposes. The stone is removed from the quarries by derricks operated by electricity. The Buckeye quarry is served by twelve derricks, six on each side, each six being run by a separate motor.

The plant is thoroughly up-to-date and strictly modern in all respects. No expense has been spared to make it one of the finest equipped quarry properties in the country The central power plant is located in a large stone power house a short distance from the quarry, and consists of four 250-H.P. Cahall type boilers, furnishing steam for four Ide engines, direct connected to three 220 kw. and one twenty-five kw. 500 volt C. & C. Electric Company generators. This plant furnishes power to operate two mills, the machine shops, five traveling cranes, twelve derricks, and all the machinery except the channelers and drills, thus reducing the power cost to the minimum. Connected with the power house is an excellently equipped machine shop, and nearby are located two sawing mills, containing all the latest appliances for turning out the finished stone product. In these



Sectional View of Sullivan Duplex Steam Driven Compressor.

A NEW AIR COMPRESSOR

The accompanying engravings illustrate a new type of Sullivan air compressor, particularly suited to the requirements of contracting, mining and quarrying work, as well as to the general purposes of industrial service, in railway and machine shops, foundries and large buildings.

This machine is of the duplex pattern, and is built in several combinations of steam and air cylinders, also for belt and power drive. The distinctive feature of these various types is the box frame, with housing, which forms a tight enclosure about the crank discs, main bearings, eccentrics, connecting rods and crossheads. This housing excludes dust and dirt, and permits the use of a system of self-lubrication of the principal working parts. As shown in the sectional view, an oil well is provided in each frame, in which the lower edges of the crank discs are immersed. The oil clinging to the discs is removed by scrapers in contact with their upper edges, and is thence conveyed by means of a storage chamber and suitable pipes, to the main journals, crank pins, eccentrics and crosshead guides, being finally returned to the well by gravity, to be used again. These machines require the minimum of attention and care, as it is necessary to add oil to the wells only at long intervals.

These compressors are very compactly and substantially built. All sizes except those of the largest capacity are mounted on a heavy sub-base, in which the inter-cooler and steam reheater (on cross compound machines) are situated. The frames are of the heavy duty or tangye pattern, with long bearings on the base, securing rigidity, and correct alignment of working parts. The steam valve gear is controlled by a Meyer adjustable cut-off, the throttle being regulated by a sensitive steam and air governor.

The air cylinders are not cored out, but instead, separate liners are forced into the castings, thus precluding shrinkage strains. The space between the liner and the cylinder forms the water jacket, and outside of this again is the air inlet passage. Incoming air is thus admitted

General View of Maselli Excavator.

EXCAVATION METHODS ON THE NEW YORK STATE BARGE CANAL

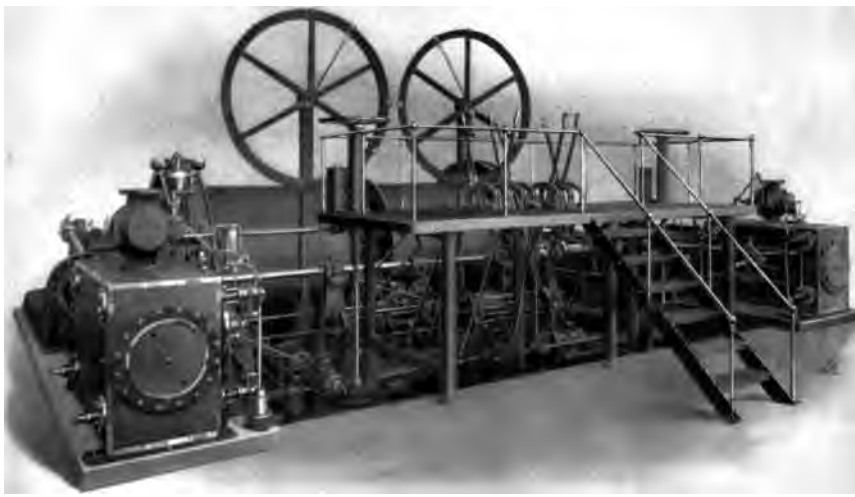
Written for Mine and Quarry by Austin Y. Hoy.*

F. A. Maselli & Co., of Rochester, N. Y., one of the contractors for the improvement of the New York State Barge Canal, are installing a large amount of equipment for completing their section near that city. The methods employed on this work will, no doubt, be of general interest to engineers and contractors.

The most prominent machine now at work on the Maselli section is a grab machine, for handling earth, loose rock, etc., which possesses some unusual features. As shown by the illustrations, the machine consists of a truss or bridge, 438 feet long over all, supported by two towers, 360 feet between centers. There is a clearance of 60 feet between the track level and the operator's room. Each tower is supported on a horizontal steel girder frame, running on 32 car wheels on railroad track of standard gauge. Running on the bridge is a trolley or car, which carries a grab dipper or bucket of the clam shell pattern, weighing, when empty, nine tons, and having a capacity of eight cubic yards. After the bucket is full, it is carried by the trolley to one end or the other of the bridge, where it dumps its contents on the spoil bank. It is stated that only one minute is required for the round trip.

Electric motors are used to operate the entire machine. Current is taken at 4100 volts from a high tension, three phase transmission line, running parallel with the canal. The high tension current is conducted to a rotary converter located in a box car attached to one of the towers.

*42 Broadway, N. Y.



Ironton Mine Hoist; Handling Motion and Auxiliary Controlling Devices.

SAFETY APPLIANCES ON FIRST MOTION HOISTS

The Ironton Mine, Bessemer, Michigan, has recently placed in service a new Sullivan first-motion Corliss hoisting engine, fitted with two machine-threaded, clutch-driven drums, each capable of holding 4,000 feet of steel rope. Duplicates of this hoist have just been installed at the Dunn Mine, Crystal Falls, Mich., and at the Colby Mine, Bessemer, Mich.

These hoists are equipped with interesting mechanism to secure high hoisting speed (2,500 feet per minute) with safety and to prevent overwinding. This mechanism comprises an automatic throttle-closing device, and an automatic stopping device. Each is driven directly from the drum, and the movable parts work in harmony with the revolutions of the drum.

The automatic throttle-closing mechanism is set so that the hoist operates with a wide open throttle until the cage has reached a predetermined point some distance below the surface, at which point the throttle is automatically closed and the cage comes to the landing by the momentum of the moving parts. On account of variation in loads, the cage sometimes fails to reach the dump by a few feet, and a small by-pass throttle is therefore provided, which admits steam between the main throttles and the engines so that sufficient movement can safely be secured to bring the cage to the landing. This throttle-closing device and the reverse engines are controlled by an interlocking mechanism, making it impossible to open the main throttles until the engine has been reversed for the down trip. An overwind under steam pressure is thus impossible.

Without this mechanism the engineer might close the throttles a long time before it was necessary, and feel his way toward the top by the brake, or he might close the throttles too late, making it necessary to bring the hoist to a violent stop.

The brake is applied in the usual manner, by means of a lever operating the steam brake engine, but in case, for any reason whatsoever, the cage should go

"Continuous Coal Cutters"

The Sullivan Room and Pillar Chain Machine

here shown at work, has an efficiency of 50 to 200 per cent. in excess of the breast machine, owing to the following facts:

(1) Machine cuts across entire face in one operation, without moving jacks or barring machine by hand.

(2) Occupies one-half as much space in front of coal. It is not necessary to move props when using this machine. (Props shown in cut are 6 ft. from face of coal.)

(3) Machine cuts high kerf, cuts on the bottom, and leaves no coal to be lifted, nor sprags or ribs at rear of cut to hinder blasting.

(4) Uses from 20 to 30 per cent less power per ton of coal cut.

SEND FOR NEW BULLETIN NO. 48-F

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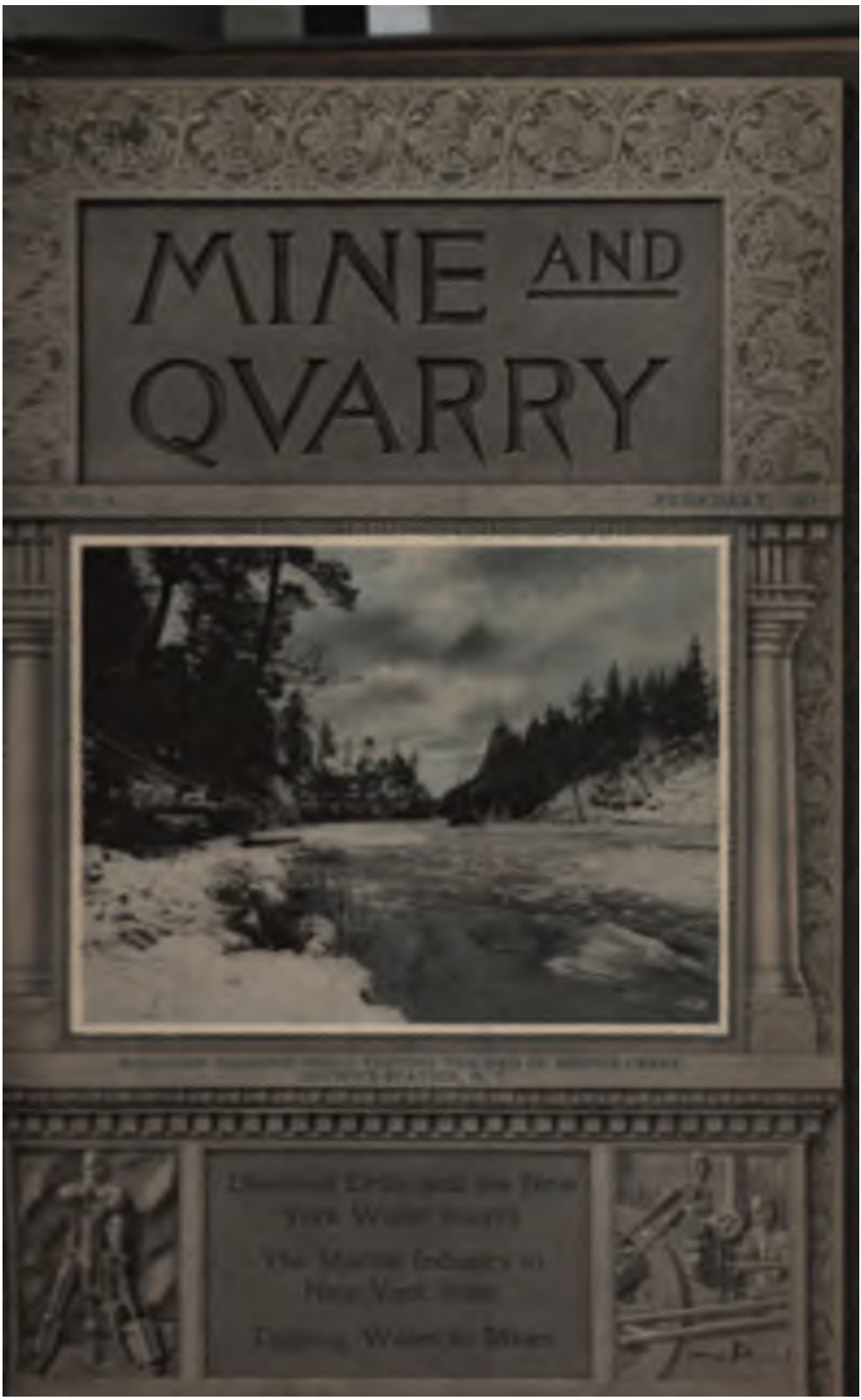
MINE AND
QVARRY

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MINE AND QUARRY

Vol. I No. 4 FEBRUARY, 1907

DIAMOND DRILLS AND THE NEW YORK WATER SUPPLY.

The use of diamond drills for making test borings, to determine the character of materials on the sites of engineering structures, has rapidly increased in the last few years. Engineers appreciate more generally than ever, the importance of knowing absolutely what formations must be encountered and what the physical properties of those formations are, before contracts are let or assumed, or the work begun. Weeks, months, or in the case of very large undertakings, years may profitably be spent in such preliminary investigation.

The Panama Canal, the Metropolitan Water Supply Dam of Boston, the U. S. dry-dock at Guantanamo, Cuba, the New York State Barge Canal route, and private enterprises, such as railroad bridges and tunnels, without number, have employed the diamond drill precisely as does a mine manager, to find out what is ahead in the way of mineral or rock, before beginning actual work. For this work the diamond drill is admirably adapted, since it secures a continuous core of all rock strata penetrated, and is provided also with tools and fittings for making wash borings in earth sections.

One of the latest and most notable of such examples of foresight is found in the preliminary test work being done by the New York Board of Water Supply, in its task of providing New York City with "enough water." Four watersheds of the Catskill Mountains, those of Esopus, Rondout, Schoharie and Catskill Creeks, will eventually supply reservoirs and aqueducts forming a chain 150 miles long, from the northern limit of the Catskill Mountains to Staten Island. The main aqueduct is to be 85 miles in length, and will empty into a distributing reservoir on the northern boundary of the city. The completed works will include at least 19 impounding and distributing reservoirs. The estimated cost of these works is $162,000,000.

Esopus Creek, yielding about 250 million gallons per day, will be the first source developed, and will flow into the Ashokan reservoir, to be formed a few miles northwest of Kingston by the erection of one large and several smaller dams or dykes. This reservoir will be 12 miles long, with an effective storage capacity of at least 120 billion gallons, the largest reservoir in the world for high pressure water supply. The water collected will cover the ground now occupied by eleven villages, to an average depth of 18 feet, forming an area of 8000 acres, with a shore line of 50 miles.

It is the policy of the Engineering Bureau to make the preliminary estimates, comparisons and investigations so thorough that all essential information shall be secured and preparation be completed before construction is undertaken or the final plans adopted. This policy is justified by the large saving in the ultimate cost of the system by avoiding mistakes and delays and by the greater efficiency of the work for which such preparation has been made.

Two sites for the main dam of the Ashokan reservoir have been considered. Approximately 15,000 lineal feet of wash and diamond drill borings and several deep shafts and trenches have been sunk to explore them. Studies by geologists and comparative estimates of cost based on the information thus gained have resulted in the selection of the Olive Bridge site, nearly a quarter of a mile below Bishop's Falls, shown in the photograph.

It is intended to construct most of the aqueduct on the hillsides, following the contours with a slope of a little more than 1 foot per mile. Where deep valleys are intersected they are to be crossed with inverted syphons, consisting of deep tunnels, driven wholly in solid rock, in some places far below the surface, and shafts, connecting with the adjacent portions of the aqueduct at grade. These syphons will be lined with concrete and

Bullivan "Badger" Drill mounted on Ashokan dam site.

roads strong enough to withstand the enormous pressure of the water. The tunnels of the Hudson River crossing may be as much as 300 ft. below the surface of the river, and hence 900 ft. below the hydraulic grade line. Valleys not exceeding 100 to 150 ft. below the hydraulic grade line will probably be crossed by pairs of reinforced concrete pipes about 12 feet in diameter or by several large steel pipes, depending on the results of experiments with reinforced concrete pipes now in progress.

In order to secure the best location of the aqueduct, preliminary lines were surveyed, covering strips in each case about 1000 feet wide, and aggregating nearly 250 miles in length. About 5000 lineal feet of borings with diamond drills have been made to explore the rock, especially at the syphon sites, besides many rod soundings along the cut-and-cover location. Borings and soundings are still in progress. The great depth of water, the tidal movement, and the large traffic in the Hudson River have rendered the examination of proposed crossings ludicrous and costly. Many lines for this crossing and its connections have been explored, extending over 20 miles of the river, from West Point to a point about four miles south of Poughkeepsie. At the site finally selected, shafts will be sunk on each side of the river, and from stations, cut at the 400-foot level, diamond drill holes will be bored under the

Another "Badger" outfit on the banks of the Esopus river.

river to test the rock formation, before tunneling is begun.

The subterranean explorations have been made with various types of boring machines, and have been executed both by the Engineering Bureau and by contractors. Among the machines in use by the Bureau are four diamond core drills, of the Sullivan "Badger" type. These are mounted on columns for use underground, but are rendered suitable for surface prospecting by telescoping back braces, resting on long skids, which also carry the drill on hinge foot-pieces. These adjustments, together with the swivel drilling head, allow holes to be bored at any angle and in any direction. For future underground work the skids and braces may be removed and lag screws inserted in the ends of the columns. At present these drills are mounted on four-wheel lumber reaches, which can go nearly anywhere that drilling is necessary. A light pipe derrick is erected over the drill hole to handle the lines of drill rods and casing. A hoist on the drill is sufficient for ordinary work, but when the rods or casing pipe must be pulled from the bottom of a ep hole at frequent intervals, in order to shatter boulders with dynamite, et cetera, an extra derrick with a hand windlass is provided. Steam is furnished from a portable boiler, also on wheels. Two views of these outfits are shown.

Mr. E. A. Clark, superintendent of borings, writes:—"We find very few places where we cannot use the wagon. Occasionally we drill in a gorge, where it is necessary to remove the machine from the wagon, fold it back onto the skids, lower it over into the gorge with tackle blocks and fall. We then place the machine on the rocks, on the ice in winter, (see frontispiece) or on a bridge over rapids, or a scow with spuds in still water.

"We frequently make borings from our wagon on side hills which stand at about 45 degrees slope. (See cut on page 88; note two-pole derrick held by guy ropes.) We have in this section, bluestone, shale, slate, sandstone, and other kinds (in boulders). We usually make from 10 to 33 feet in eight hours, taking a 1½-inch core. While you sell the machine for a 15-16-inch core to a 500-foot depth; I believe it would easily take a 1⅛-inch core to a 600-foot depth. I wish to say further that for a rough country, where

Sullivan "S" Drill at Blake's Farm, Walkill Valley Crossing.

Bishop's Falls, above Ashokan dam site, 100 feet below high-water level.

miles long. The surface conditions here were exceedingly difficult for drilling operations. The bed-rock, a soft slate, standing on edge, and badly broken, drops rapidly away from the foot of the hills toward the river gorge in the center of the valley. As the depth of the wash increases, boulders become more numerous, and at the greatest depth of surface deposit, they are literally piled together with intervals of a few inches of coarse gravel. These boulders were grit fragments carried down from the mountains, and it was found impossible to blast them without first boring through them with a diamond bit. On this section the contractors used a Sullivan "S" friction feed drill, mounted with boiler and pump, on trucks, and two Sullivan "M" hand power machines, one belted to a Minnesota pipe driving rig, and the other to a five-horse power hoisting engine, with a friction drum for driving pipe.

Wash borings were made in the usual way with double pipes driven by hydraulic jets and hand hammers, the details of the apparatus having been adapted from those ordinarily used for such purposes. There are twelve wash drilling parties, each of them consisting of four men, besides a recorder, who in some cases takes notes for two or more drilling parties.

The records of the drilling parties are kept on daily report sheets and filed in the department offices. The blank for diamond drill reports gives the foreman's name and has vertical columns for the identification number for the hole, the previous number of feet and the number of feet drilled each day. The column footings show the total depth of each test hole and at the foot of the page spaces are reserved for statement of the number of single and double teams used and laborers, etc. The blanks for the wash borings give the name of the line, serial number for each hole, the number of feet previously driven and the number of feet driven on the current day

TUNNELING WITH A CHANNELER.

ation. The machine was run by compressed air, and used a three-piece gang bit. It stood 5 feet 6 inches high, was 4 feet 4 inches wide on its track, and 4 feet 3 inches long. This machine weighed about 1800 pounds, and had a 4½-inch cylinder.

After the side wall cuts had been completed, the rock between was drilled and blasted in the usual manner, Sullivan US (2¼-inch) rock drills being employed for the purpose. The entire tunnel, 400 feet in length, was driven successfully in this way, without trouble from the roof. The rock was tough flint for about 100 feet, the remainder being limestone. The channeler cut 24 lineal feet 8½ feet deep in the flint, during the first five days it was at work. Later, progress was more rapid, since the cuts were made in two lifts and the limestone was not so hard on the bits. The contractors were much pleased with the successful manner in which the channeling machine solved their problem.

AMERICAN DRILLS IN A FRENCH COLLIERY.

The largest coal mining company in France is the Mining Society of Lens, in the Pas-de-Calais district, producing over 3,000,000 metric tons per annum, or between nine and ten per cent. of the entire production of the country. The magnitude of the enterprise may be in some degree appreciated when it is stated that there are sixteen working shafts, employing over 13,000 miners, who, with their families, comprise a population of over 65,000, occupying more than 6000 houses in Lens and the surrounding villages. There are over 19 miles (in 1903) of main underground roadways, and the equipment includes (1903) 21 hoisting engines, 29 mine fans, 20 air compressors, 39 haulage locomotives, and over 350 rock drills, representing a combined horse power of over 25,000.

Practically all the coal is won by hand, owing to the method of mining. The veins pitch at a steep angle, and are badly faulted. They average about 33 inches in thickness. From the main roadways, horizontal galleries are driven along the vein, the lower portion being in the coal, the upper portion in the solid rock. These galleries are 6 feet 6 inches high, and about nine feet wide. They are driven from 65 to 175 feet apart, and the coal in the vein is then mined between them, from the lower to the upper gallery. This is in effect, modified stoping. The roof is weak, and is carefully supported by props, and broken rock brought in for the purpose. Shoots or passageways are left at intervals, down which the coal is dropped to the lower gallery and there loaded into cars. Ventilation is controlled by means of doors at the foot of each shoot, so that the air follows the working face. The accompanying rough sketch (page 94) illustrates this method of work.

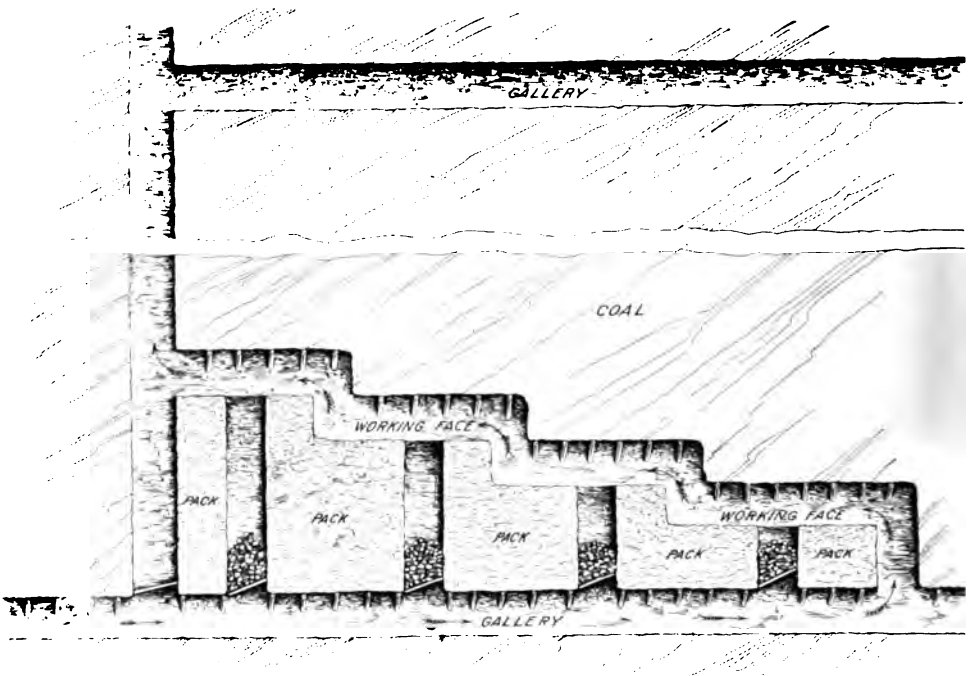
As stated, the pitch of the vein is too steep for machine work. In the entries or galleries, Sullivan Coal Pick Machines are in limited use for undercutting the coal, and rock drills are employed for taking down the roof, which is usually three feet thick and the full width (9 feet) of the working.

Until a few years ago, drills of European make were employed entirely. These machines are large and heavy in design, two of them being permanently mounted on a movable truck. In driving the galleries these machines are able to remove the central portion only, leaving a shoulder on each side wall.

American rock drills, of standard Sullivan "US" (2¼-in.) pattern were tried some half-a-dozen years ago and it was found that four of these drills, mounted on mining columns, could put in a round of 20 holes which permitted the entire heading to be shot at once; whereas it

"Science guides the work of mining." — See criticism 1, page 88.

was necessary for the European drills, working on their brackets, to put in 24 holes, even then leaving the shoulders untouched to, which had to be drilled and blasted later. Eight shafts, ranging in depth from 200 to 800 feet, and from 18 to 21 feet in diameter, have since been sunk with T.S. drills mounted on tripods. The colliery management is greatly pleased with the American drills, on



Method of coal mining at Lens, France. The arrows show the direction of the air current.

account of their light weight, one third that of the French machines, economy of air and repairs, and greater drilling speed. Between 60 and 70 of the Sullivan US type are now in use, and are replacing the French machines as new drills are needed. The plate on the preceding page is from a photograph of a bronze bas-relief panel which was recently placed above the fireplace in the main room of the company's new office building at Lens. The Sullivan drill, as will be noted, occupies the most prominent position, next to that of Science. The figure of the hand miner below, illustrates the height of the coal, the props which are everywhere necessary, and the safety lamps always used, owing to the presence of gas in the workings.

There is much about this great colliery which would be of interest to American coal operators. The problems encountered in shaft sinking, methods of hoisting and shipping coal, haulage, ventilation, pumping, the life of the miners and their work above and below ground, all contain lessons which mine managers in this country might study to advantage. We cannot forbear to mention a provision for safety which might be put in force to advantage here:—The depth of drill holes for blasting is restricted to one and one-half meters, or about five feet, and when a shot is missed, the hole must be drilled over; the miner is forbidden to touch a hole after it has once been fired.

For information used in this article MINE AND QUARRY is indebted to Mr. A. de Gennes, M. E., of Paris,* who was for several years superintendent of two of the Lens openings.

*No. 25 Rue Raffet.

THE MARBLE INDUSTRY IN NEW YORK STATE.

Mill and Crane-way, South Dover Marble Co., Wingdale, N. Y.

Marble suitable for building and monumental purposes occurs in New York state in two principal localities,—in Dutchess and Westchester Counties in the southeastern portion, and in St. Lawrence county in the northern part of the state.

The South Dover Marble Co., with quarries at South Dover, is the largest single producer in the state, and its methods of operation are typical of the quarries in the southeastern field. South Dover is in Dutchess County, close to the Connecticut line, and 70 miles northeast of New York City. Wingdale, three miles distant, is the railroad station, on the Harlem branch of the New York Central lines. The Company's mills and finishing works are here and are connected with the quarries by a private trolley line.

The quarries were opened more than 100 years ago, to work the deposits of dolomite which there occur to great depth. Owing to their inaccessibility, however, they were not fitted and worked with modern machinery until some 12 years since. At this time the electric freight railroad referred to was installed. When first opened the marble was all hauled by teams over the mountains to Poughkeepsie, 25 miles away, and shipped from there by water. The beds slope gently to the east, and are very regular and free from veins, fissures or intrusions of other rocks, a fact which permits solid blocks of pure marble of very large dimensions to be removed for columns and similar purposes. The illustration on page 97 shows a block 29 feet long, weighing 40 tons, being lifted from the quarry. This formed one of 64 monolithic columns, ranging in length from 21 feet 6 inches to 29 feet ten inches, furnished by this quarry two years ago for the Tiffany Building in New York City.

The quarry opening is about 200 feet long and ranges from 50 to 140 feet in width.

The view on page 96 is from the north side of the quarry, looking south. At this end of the quarry the stone is all of the "White South Dover" variety. In the north end, partly shown on page 98 a popular colored marble is found.

Stone has been excavated to a depth of about 120 feet from the higher side of the hill, and 86 feet from the lower. The marble is excavated by means of Sullivan Class 6½ direct-acting stone channeling machines, of which nine are now in use. One or two other machines

The South Dover Marble Co. General view of quarry, showing Sullivan Channelers and Gadders at work.

The north end of the South Dover quarries. A Sullivan Double Head Channeler is in the center.

with a 36-foot bed and a capacity for turning columns 11 feet in diameter. This is the largest marble lathe in the United States.

The mill is large [illegible] and has been remodeled with a new [illegible] and the electric traveling cranes [illegible] Dickson engineer. In the setting of the frame a novel device was used [illegible] bed. The engagement [illegible] between bearing beds of [illegible] and engines. There is apparent in the [illegible] generation of [illegible] which are driven by [illegible] engine drives the [illegible] by the gang saws. There is also an air compressor which supplies the [illegible] with motive. The boiler plant is rated at [illegible] horsepower.

The company employs about 100 men and reports a rapidly increasing demand for the various grades of marble.

Marble shows that has been employed for building purposes in all parts of the country, particularly on work requiring large slabs or columns as monolithic shafts. It is largely used for interior decoration, but stands weather as well that [illegible] has been employed more extensively for outside work. Among the buildings in which this marble has been used during the last few years are the Tiffany Building, New York; Metropolitan Life Insurance Building, Madison Square, New York; Metropolitan Life Insurance Building, Twenty-third Street, New York; Mutual Life Insurance Building, Broadway, New York; Stock Exchange, interior, New York; Equitable Building, New York City; The Chicago Office Building and the Monumental Building, Washington. The Cleveland Trust Co., Cleveland; the Equitable Trust Co., Cleveland; the Equitable Building, Denver; Colorado; Equitable Building, Portland, Oregon; Equitable Building, Seattle, Washington; Equitable Building, Tacoma, Washington; Equitable Building, Spokane, Washington; Equitable Building, Los Angeles, California; Equitable Building, San Francisco, California; Equitable Building, Oakland, California; Equitable Building, Sacramento, California; Equitable Building, San Diego, California; Equitable Building, Fresno, California; Equitable Building, Bakersfield, California; Equitable Building, Stockton, California; Equitable Building, Modesto, California; Equitable Building, Merced, California; Equitable Building, Visalia, California; Equitable Building, Hanford, California; Equitable Building, Lemoore, California; Equitable Building, Coalinga, California; Equitable Building, Taft, California; Equitable Building, Maricopa, California; Equitable Building, Fellows, California; Equitable Building, McKittrick, California; Equitable Building, Buttonwillow, California; Equitable Building, Wasco, California; Equitable Building, Shafter, California; Equitable Building, Delano, California; Equitable Building, Earlimart, California; Equitable Building, Pixley, California; Equitable Building, Tulare

crop is cleared of broken stone and earth, and a water sump is made at the lowest point of the ground to be worked, with rock drills and dynamite. A crane is set up at the edge of the sump, and the ground is leveled off for channeling. The machines used are the Sullivan Class 6½, with five-piece gang steel and swivel head, capable of cutting at any angle. Steam is supplied by the mill boilers, through pipe, with flexible joints, which permit the channelers to move freely back and forth on their track, usually 30 feet in length. The accompanying cut shows one of these machines. The White Crystal Marble Co. also employs a Sullivan Class Y channeler, with rigid head, which carries its own boiler. These machines have a feed engine, which propels them along the track at a speed adjusted to the hardness of the cutting. The engine reverse lever is attached to a long rod which is close to the rail and parallel with it. When the machine reaches the end of the track, this rod strikes a dog fastened to the rail, thus reversing the channeler automatically. The Class 6½ channelers cut from 30 to 60 square feet per ten-hour day, and work to a depth of six feet. The Gouverneur Marble Co. still employs one or two of the old style Sullivan Diamond Channelers, which preceded the direct acting steel type. The high price of diamonds has caused the general abandonment of this machine, which is otherwise efficient and economical of stone.

In opening a new quarry, after the sump is cut out and the derrick set up, as described above, two parallel channel cuts are made, usually 60 feet apart, and at right angles to the sump, rising from

The craneway and finishing works, South Dover Marble Co.

Bullivant Class 6 Single Deck Mobile Conveyor

TAPPING WATER IN MINES.

The method of removing large bodies of water from old mine workings by means of a diamond drill hole bored from a lower level is not so unusual as suggested by the article, "A Novel Use of Diamond Drills," printed in the August number of this paper. Some 20 odd years ago a hole over 200 feet long was bored under a Chicago city street to drain the stagnant water in an old quarry pit into an active quarry below. The angle of this hole was about 45 degrees, and its actual length was within a few inches of the surveyor's estimate.

The Enterprise mine of the Lehigh Valley Coal Co., near Wilkes-Barre, Pa., which has been idle for over 20 years, on account of the advance of the water, was drained a few weeks ago by this means. A bore hole 300 feet long, drilled from the adjoining Henry colliery, tapped the mine successfully, and has drained off the water in the higher levels, permitting the mining of thousands of tons of good coal. The lower levels are to be drained by pumps.

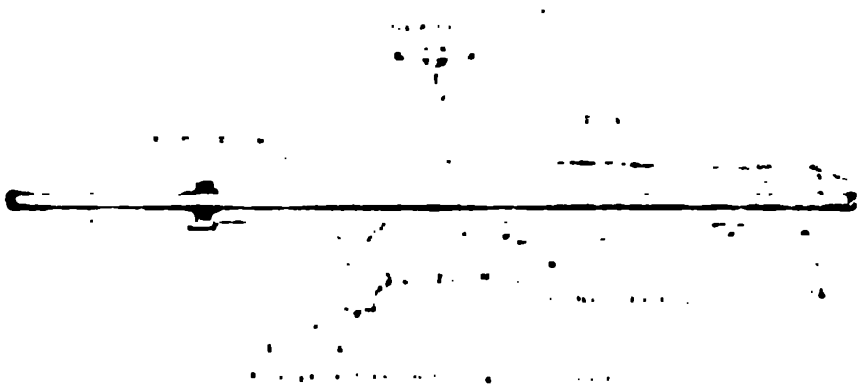
The *Engineering and Mining Journal* recently contained a letter from Mr. H. A. Horsfall, of Yonkers, N. Y., describing mechanism for controlling the flow of water when the old workings are reached. The accompanying sketch shows the method. The bore hole is reamed out for a short distance, and a piece of pipe inserted, with a coupling at the inner end to hold the pipe in place when the water pressure is turned on. The pipe is packed with oakum and wedged into the hole with pine wedges. A stuffing box at the outer end permits the drill rods to rotate freely, and a stop cock is provided to draw off the drilling water and cuttings. The gate valve controls the flow of water.

An Australian correspondent sends a report from Mr. M. Russell, Inspector of Mines at Charters Towers, in Queensland, which describes the process of tapping and removing the water from drowned workings, in some detail. The use of an improvised air lift to drain the mine will be found interesting by users of compressed air. The boring was done with a Class "C" Sullivan diamond drill.

"Regarding the tapping and removal of subterranean accumulations of water referred to in a previous monthly report, I beg to forward a brief outline of the method carried out at the Brilliant Stockholm Mine. After many years of idleness, the Stockholm Mine, lying some seven miles west of this town, was taken up by the Brilliant P. C. Company, who on starting operations decided upon sinking a new vertical shaft to cut the reef some distance below the old workings which were at that time full of water. The new shaft passed through the reef in solid country at a vertical depth of 525 ft., the nearest point in the old workings being some 100 ft. away or more. The question of cheaply and effectively removing the large accumulation of water in the old workings then presented itself to the company. To pump the water through the old shaft meant the expenditure of a large amount of money, besides which the task of picking up the old underlie would have been costly and at the same time a hazardous one.

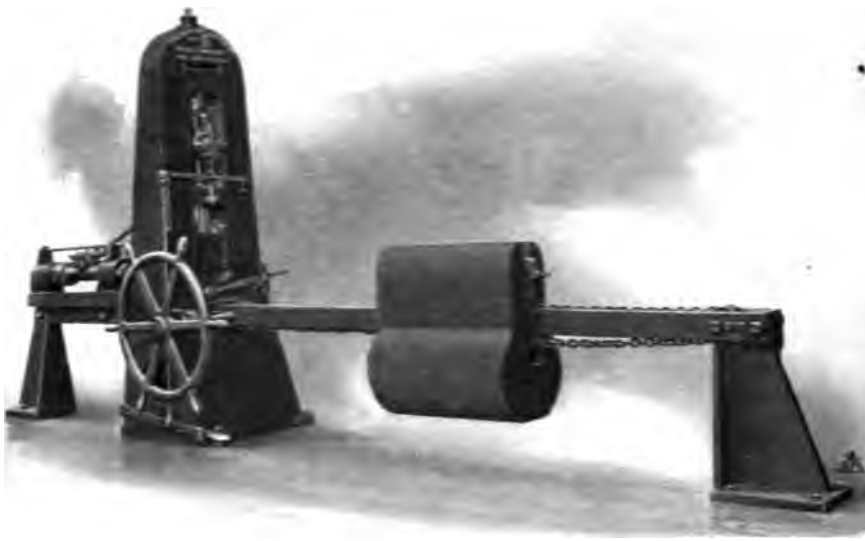
"After carefully considering the matter, the company decided upon tapping the water by means of a diamond bore, and arrangements were entered into with the Goldfields Diamond Drilling Co. to carry out the work. At a point in the new shaft, 440 ft. from the surface, the boring machine was duly installed, and a $1\frac{3}{4}$-inch hole put in for a distance of 40 ft. The boring rods were then withdrawn, and 15 ft. of the hole reamed out to 2 in. A 2-in. pipe fitted with a gate valve, and pressure gauge, was next forced into the hole and secured by means of cement. The rods were then passed through the pipe and boring was resumed, the old workings being tapped at a distance of 117 ft.

"While the operation of boring was in progress, a column of 3-in. pipe was



THE MECHANICAL SHARPENING OF ROCK DRILL STEEL.

By Matt. Brodie, M. E.*



The "Numa" Rock Drill Maker and Sharpener

It is a well demonstrated fact that the accuracy with which drill bits are formed and sharpened greatly influences the capacity of a rock drill. The maintenance of drill steels is an important item in the cost of rock drilling, and during the past few years the making and resharpening of drill bits by machinery has undergone a rapid extension and reached a thoroughly practical stage. Almost every mine using a considerable number of drills, today includes one or more drill-sharpening machines in its equipment.

The different machines on the market are similar in general design, and usually consist of a horizontal hammer for upsetting the steel, a vertical hammer for drawing out the bit edges and an adjustable anvil block. The superiority of any one machine over others consists in its strength, speed, simplicity of operation and the perfection of the finished bit. In virtue of these qualities the "Numa" Drill Steel Sharpener, invented and manufactured by J. J. Brossoit, Salt Lake City, Utah has found extensive use by the larger mining companies and contractors throughout the west, and is being shipped to the Michigan districts and to British Columbia.

A glance at the accompanying general view will give some idea of the strength of construction. The main vertical frame is cast in one piece and has a very liberal base, insuring a minimum vibration under the most severe service. This frame is cored out for the vertical engine frame. The anvil block is provided with roller bearings and is supported on a single rectangular rail, extending the entire length of the machine. The adjustment of the anvil block, for different lengths of steels and for upsetting, is effected by means of a chain running from the main frame to the front end, and a large hand wheel on the operator's side of the main frame. This block is of

*128 Keith Building, Salt Lake.

one man will sharpen about 60, and with a helper about 90 drills per hour. These figures are not what would result from a short test run, but are what should be expected as an average per hour for the entire shift.

One of these machines was installed at one of the large copper mines in Bingham, Utah, about two years ago and below are tabulated the labor costs per shift for sharpening drill steels before and after installing the machine:

BY HAND.

3 Blacksmiths at $3.50	$10.50
3 Helpers at $2.75	8.25
Total	$18.75

BY MACHINERY.

1 Blacksmith	$3.50
1 Helper	2.75
Total	$6.25

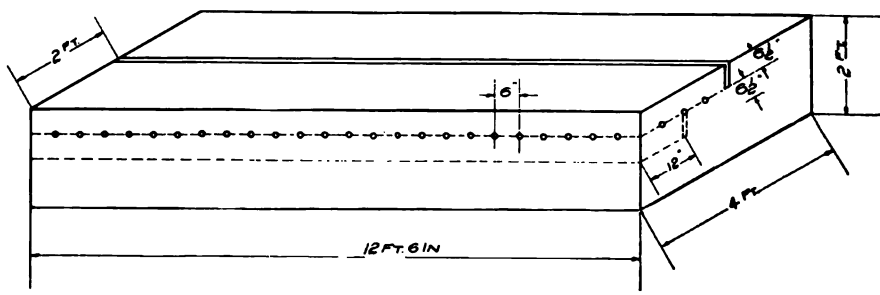
A saving in labor cost of 66 per cent, or $12.50 per shift.

CHANNELING GRANITE WITH HAMMER DRILLS.

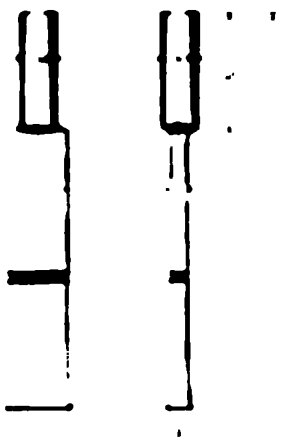
The accompanying sketch illustrates an instance of labor saving in quarry practice, by means of a new type of air hammer drill. The work done consisted in cutting one of a set of steps out of a solid block of granite, at the quarry of Jones Bros., Barre, Vermont. The steps were each 12 feet 6 inches long, one foot wide and 6½ inches high. The step removed, being the first, was two feet in width, as shown by the rough sketch. The drill operator first sank a line of 1¼-inch holes along the back of the step, ¾-inch apart. He then broke out the partitions, using the broaching bit shown in the second sketch. This part of the work required only a few seconds for each partition. When this channel was finished, plug holes were drilled on the side and ends of the step, and the whole block of stone split off bodily. The quarry manager was greatly pleased with the result. The usual method, hand hammer and bull set, would have taken one man a week, whereas the drill did the work in half a day.

Barre quarrymen expect to apply the same method to much of their ornamental and monumental work, such as cutting out crosses, watering troughs, and in fact any pieces of irregular shape which may be roughed out of the solid stone by means of channeling. The machine used in the instance described was a Sullivan Foot Hole Drill, class D-19, using hollow drill bits and weighing 30 pounds. Its cylinder diameter is 1¼ inches, and it uses about 25 cubic feet of free air per minute at 100 pounds pressure. It is suitable for drilling holes up to 1⅝ inches in diameter, and from one to four feet in depth.

Air is admitted by a push-handle throttle, which is opened when the runner presses the drill against the rock, and closed when this pressure is relieved. The hole is cleaned by the exhaust air, which passes through the drill



Plan for channeling steps from a granite block.



AMOUNT OF POWER CONSUMED IN CUTTING COAL.

The amount of power required to cut a given amount of coal is an important consideration in installing a machine mining plant. The actual power consumed by air pick machines in cutting a cubic inch or foot of coal is hard to determine with exactness, owing to pipe line leakages, use of the air for other purposes, fluctuations in steam and air pressure, et cetera. In the case of electric machines, however, portable instruments have been perfected which may be attached to the mining machine itself, and which register the quantity of power consumed with accuracy. By means of a series of readings, the operator may determine just how much power is used by a given type of machine in cutting a given quantity of coal.

There are two distinct classes of electric chain coal cutters in use in this country for room and pillar mines: The breast machine and the Sullivan "continuous cutting" type. There are several designs of the former, which all work on the same principle. The machine is controlled by front and rear jacks, and is fed under the coal, making a cut from 30 to 42 inches wide and four or 4½ inches high. The machine is then backed out, and barred along the face, by hand, to make a fresh undercut. The jacks must be torn down and reset each time. This process is repeated until the room is crossed. The accompanying sketch (No. 1) shows this method. It may be observed that power is lost each time the machine is backed out from the coal, also in hand-barring, changing of jacks, et cetera, to say nothing of the fact that the second cut must overlap the first sufficiently to prevent the formation of a sprag or rib between the cuts.

The Sullivan machine is practically an adaptation of the long wall principle to room and pillar work. The machine

Sullivan Chain Coal Cutter: Completing the "sumping" cut, and detaching pan, or rear half of frame, before cutting across the face.

Place	Machine	No. of cuts or width of room	Depth of cut, inches	Width of cut, inches	Height of kerf	Average load H. P.	Ft. lbs. per cu. in. of coal cut	Time for cut, min.	% power saving Sullivan over competitor
Carneyville, Wyo.	Sullivan Breast Type No. 1.	18″ per min. 1 cut	78 84	* 38	6 4	16.8 11.5	65.8 105.79	3.50	.378
Sturgis, Ky.	Sullivan Breast Type No. 2.	68′10″ 6 cuts	78 60	* 33	5¾ 4	23.5 16	186 431	75 36	.569
Linton, Ind.	Sullivan Breast Type No. 3	30′5″ 5 cuts	66 63	* 29	5¾ 4	16.7 10.75	135 156	33.5	.135

* See Column 3.

more favorable than indicated, since this machine was unloaded, loaded and moved from place to place along the face of the coal under its own power, which was measured and included in calculating the average load. It was not possible to determine these factors for the breast machine tested, so that the power shown is merely that consumed in actually cutting coal. This was also the case in the second test recorded in the table.

The "continuous cutting" type of coal mining machine possesses other important advantages over the chain breast pattern. Since the cutter bar is at all times under the coal, and the pan or rear half of the frame is detached after the sumping cut, the machine occupies from

Sullivan Coal Mining Machine crossing the face in one operation. The props shown are only 6 feet from face. They need not be moved to permit the passage of the machine.

per cent. went for labor, and 13 per cent. for carbons. The cost of drilling in soft schist rock was as low as $1.00 per ft., of which labor formed 66 per cent. and diamonds 30 per cent. The cost of drilling in hard syenite rock was twice that of drilling in tough diorite, the cost of the diamonds in drilling the syenite rock approximated 63 per cent. and the labor 38 per cent; in the diorite rock the carbon cost 30 per cent. and the labor 66 per cent. of the total. The speed of drilling varied from 6 to 25 ft. per day, and the holes had a mean diameter of 1¾ inches."

The following extracts from an article on Diamond Drilling in the Boundary District (B. C.) will be of interest in this connection, (read by Mr. Frederic Keffer, Manager of the British Columbia Copper Co., Greenwood, B. C., before the Canadian Mining Institute): –

"As an adjunct in prospecting and developing the low-grade ore deposits of the Boundary, the diamond drill has proved an unqualified success. As these great ore-bodies have been opened up, it has come to be more and more apparent that the ore exists in irregular masses with usually no very well defined walls (except where it lies in contact with limestone). Further the deposits are frequently separated by barren zones, so that when the boundary of an orebody is reached it is quite impossible to predict whether more ore will be found beyond or not. Commercially, the low grade of the ore prohibits crosscuts or drifts being run in barren ground solely in order to prospect it, the only allowable dead work being that necessary to reach known deposits.

"It is under these conditions of necessary economy and uncertainty of ore occurrences that the diamond drill has become so useful, not the least of its value being negative, for knowing where the ore is not to be found is only secondary to finding it.

"Most of the drilling done under the writer's direction has been done by day labor, this having been found to be more

1. PROGRESS TABLE.

	April May	June	July	August	Sept.	Oct.	Nov.	Dec.
Shifts	37	26	26	27	23	27	26	25
Feet drilled	304	253½	259½	295	250	245	278½	356
Hours drill was run	231	167	149½	194	164½	142	170	167½
Hours setting diamonds, moving machine, etc	57	44	79½	22	19½	101	38	32½
Feet per shift	8.21	9.75	6.98	10.93	10.87	9.07	10.71	16.24
Feet per running hour.	1.31	1.52	1.74	1.52	1.52	1.72	1.64	2.13
Carats used	6.⅞	6.⅞	7.⅛	5.⅞	6.⅛	4.¾	7.⅛	2.⅝

(Note—Underground shifts are 8 hours. Surface shifts 9½ hours.)

2. COST TABLE.

Labor	403.60	272.00	260.88	271.00	210.35	219.60	226.50	231.75
Diamonds	328.81	342.99	382.81	298.45	299.18	227.73	434.85	114.83
Power, etc	13.46	29.10	30.56	26.76	25.13	31.78	18.49	118.97
	745.87	644.09	674.25	596.21	534.66	479.11	679.84	465.55
Feet	304	253.5	259.5	295	250	245	278.5	356
Cost per foot	2.45	2.54	2.60	2.02	2.14	1.95	2.44	1.31

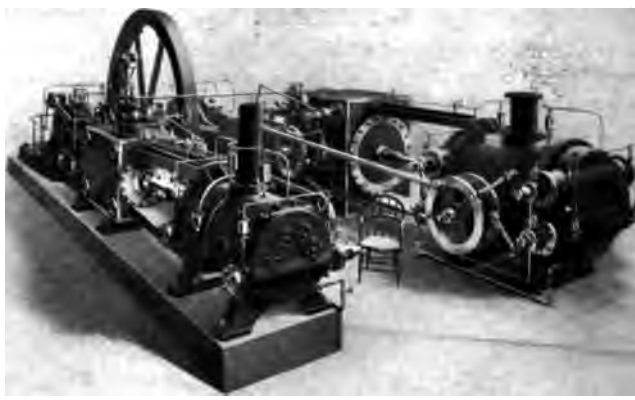
satisfactory than contract work as well as more economical.

The daily reports are tabulated and the results of each month's working are compared with those of the previous month. In this way the progress of the mine is carefully watched, and any falling off in efficiency is at once detected.

The tabulated results are preceding pages may be useful to those contemplating

PERSONAL

Sullivan Air Compressors



SULLIVAN-CORLISS Air Compressors are the highest type of machinery for producing air power.

They combine the best steam economy and air efficiency with the lowest cost for maintenance and repair.

These qualities are secured by distinctive features of the Sullivan designs, and by the Sullivan engineering standards in materials and construction.

A new catalogue, No. 58 M, describes these machines, as well as the Sullivan straight line and duplex types.

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SAN FRANCISCO

MINE AND QVARRY

THE McCALL FERRY POWER DAM ON THE SUSQUEHANNA RIVER

Air Power in Dam Construction

Lead and Zinc Mining at Joplin

Navigation

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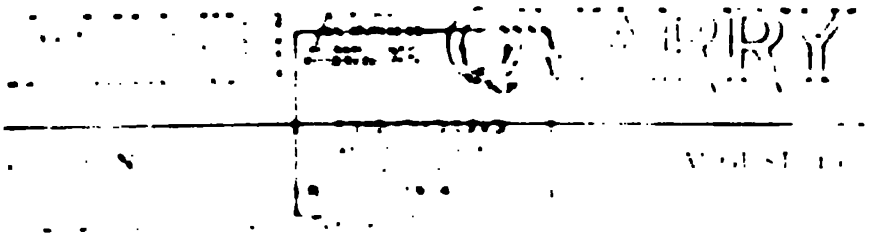


General view of the McCall Ferry Dam and its location.

AIR POWER IN THE CONSTRUCTION OF THE McCALL FERRY DAM.

WRITTEN FOR "MINE AND QUARRY"

By L. R. Chadwick, M. E.*

The use of compressed air in large engineering undertakings is no longer confined to the operation of drills and channelers for rock excavation. By means of a central plant, power may be supplied to contractors' machinery of every description, at a cost far below that of steam, and with much greater convenience.

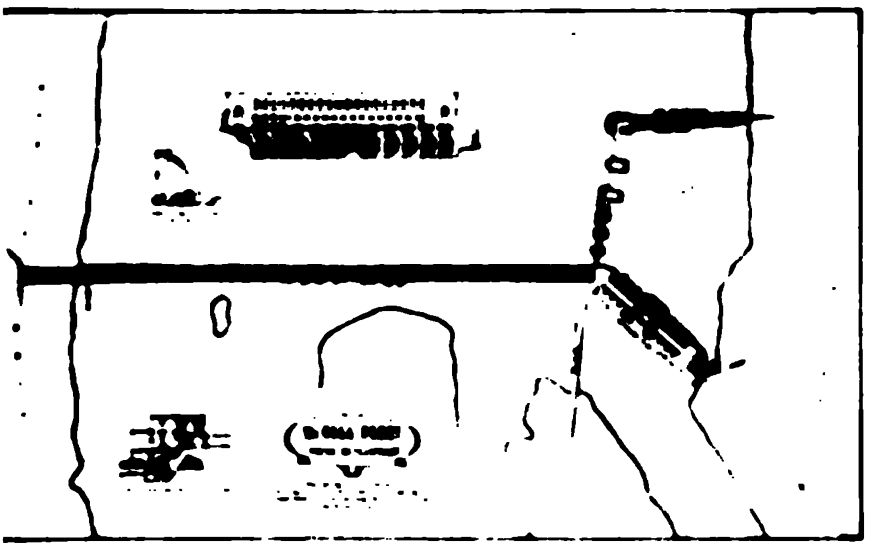
THE MCCALL FERRY POWER CO.

A notable example of the advantages of compressed air for such purposes is that afforded in the construction of the water-power dam across the Susquehanna River at McCall Ferry, Pa., by the McCall Ferry Power Co., of New York. The power developed by this installation will be converted into electrical energy, to the delivered capacity of 100,000 horsepower, and distributed, for lighting and manufacturing purposes, to neighboring cities. The enterprise, which involves the expenditure of $2,500,000, ranks first among the numerous developments of water power now under way in this country, and in point of magnitude and engineering difficulties is equalled by few single or isolated undertakings in progress.

The river is 2,500 feet wide at this point, and the dam will have a total length of 3,000 feet, including the sections which extend upon the land. It is 65 feet wide at the base, 10 feet wide at the crest, and 55 feet high; and it will raise the water level to a point 15 feet higher than at present, impounding a lake six miles long, a mile wide, and 30 feet in average depth.

The work began in October, 1905, and is now more than half completed. The general plan consists in laying bare first one-half of the river, by means of a cofferdam, and then the other, building the dam in two sections. The presence of Fry Island in mid-stream made this plan feasible. The diagram on page 143 shows the relative location of the dam, power-house, and of Fry Island, while the photograph above gives an idea of the river and its banks at this point.

* 42 Broadway, New York.



emptied, a construction bridge of solid concrete masonry was erected, from which to build the dam. This plan was adopted on account of the heavy floods which frequently occur on the Susquehanna, necessitating a system which would permit the placing of concrete in the dam even when the foundation was under water. The construction of this bridge, shown on page 145, was an engineering feat in itself, particularly in the speed with which it was built. It connects the eastern shore with Fry Island, is 1,100 feet long, and wide enough for four railroad tracks. The arches are 40 feet wide and from 20 to 50 feet high, and the entire bridge was completed in 45 working days.

Meanwhile, a concrete mixing plant had been set up, having a total capacity of 3,000 cubic yards per day. A quarry was opened at Conowingo, 14 miles down the river, to supply stone for the concrete. The river bed was thoroughly cleaned and tested, in preparation for the foundation. The construction of the foundation and of the dam is carried on by means of pelican cranes, five in number. The concrete is delivered to the cranes in one-yard steel dump buckets, loaded on trains of flat cars. These trains consist of five or six cars, with two buckets on a car, and are drawn by "dinky" locomotives. As the train arrives between the vertical members of a crane, the bucket is lifted from the car, transported laterally to the desired place, and there lowered and dumped.

The processes of mixing the various grades of concrete, handling the loaded cars and returning the empties, are performed with wonderful speed and accuracy, possible only by means of the thoroughness of organization, even to the smallest details, which is characteristic of this undertaking.

The Air-Compressor Plant in course of erection.

The Construction Bridge.

THE DAM STRUCTURE.

...e photographs on pages 142 and 149 ... the typical structure of the dam. ...section on the island is built of solid ...ete, but that which crosses the east-...channel consists of piers 40 feet ... and 30 feet apart. The foundation ...ld and is built to a height of four or ... feet above the present level of the ... The cofferdam, which laid bare ... channel, has now been removed, ...ing the river to resume its course, ...ng through the intervals between ...piers. The cofferdam in the west ...nel is finished, diverting the entire ...ly to the east channel. The western ...n of the dam will be built solidly ... the shore to the island from a ...portion bridge like that employed ...he eastern channel. When com-...ed, the cofferdam will be torn out, ... the intervals between the piers ...he east channel closed, one by one, ...mixed rein-forced and concrete, com-...ing the main spillway.

...he dam is rounded off at the top on ...up-stream face. The down-stream ...e is carried to a parabolic convex sur-face, fuller than that assumed by a mass of water running over the crest to the maximum depth. The effect is to cause the water to hug the surface closely and thus make impossible the formation of a vacuum between the dam and the over-flowing water. About halfway from crest to toe the curve reverses, so as to shoot the water away from the dam in a horizontal direction. This will prevent scouring of the foundations.

This curved spillway has involved a structure founded securely upon bed-rock, which, as to both shear and tension, is many times as strong as the most liberal factor of safety requires. To pro-vide for expansion and contraction, and so avoid the internal strains so dangerous to such a structure, the dam is built in sections of 40 feet, between which layers of compressible material are introduced in a vertical plane. Even with extreme variations of temperature the dam will not be subjected to harmful stresses.

The consideration of avoiding inter-ruption in service by ice during flood times has led to the adoption of ice guards on a liberal scale and complete in character. The ice will naturally take

The Air-Power Plant, consisting of two Sullivan Corliss Air Compressors.

Construction Bridge, Forebay, and Part of the Dam.

machines by steam are easily seen. The cost of producing the requisite amount of air with compressors of the Corliss cross compound condensing type, developing a horsepower on from 14 to 16 pounds of feed water per hour, and the resulting low fuel consumption, is much less than the cost of steam to do the same work. The loss in transmission of air power is very slight as compared with the loss due to condensation in steam pipes. An expensive system of distribution of water and coal is avoided. Individual boilers for the hoisting engines, as well as firemen to tend them, are dispensed with. Repairs on such boilers, which would be great, owing to the inferior class of labor necessarily employed, are saved. The increased comfort to the men arising from the absence of heated parts about the machines, greatly facilitates the progress of the work.

At the quarry, some fourteen miles away, where the crushed stone for use in construction is prepared, an 1,160-foot Sullivan class WB-2, straight line, simple steam, two stage air compressor drives a number of rock drills.

Such have been the demands of the work that since the compressors at the dam were installed in May, 1906, they have frequently had to run during the entire 24 hours for several days at a time, yet at no period has the work been held up for want of air pressure, and the cost of repairs has been practically nothing. The compressor at the quarry has several times been heavily overloaded, yet it has always been able to meet the requirements on it without the slightest indication of a break-down. All three of the compressors, as well as the Sullivan drills, in use about the dam and at the quarry, have done their work in a thoroughly satisfactory manner, and receive the heartiest commendation of the engineers in charge.

Acknowledgment is tendered the Power Company's engineers for photographs and information used in preparing this article.

SOAPSTONE.

By G. M. Bertram, M. E.*

A great deal is known about building stone for exterior and interior purposes, such as marble, granite, sandstone, and slate, from the single fact that immense beds of these formations are found in various sections of the country. Soapstone, however, cannot be classed with these other stones, owing to the narrowness of the veins or deposits in which it is found, and the limitation of the working quarries to a single section of the country.

Location of the deposits.

Take a map of eastern North America, and draw a line parallel to the mountain ranges, about twenty miles east of the Blue Ridge. This line will pass through, or very close to, the working talc and soapstone veins of this country. In North Carolina the formation first appears in the form of talc, which gradually hardens as it enters Virginia, until the first active soapstone quarry is reached in Campbell County. Following the line to Nelson and Albemarle Counties, the chief soapstone-producing section of this country is reached. At the present time ten quarries are being worked here, some of them just opening and others that have been producing soapstone for from fifteen to twenty-three years. Further north, in Orange County another quarry is opened, and again in Fairfax County. This latter, however, is only producing soapstone dust. In Carroll County, Maryland, another quarry is producing regular soapstone products and dust. The vein is found in the form of talc and serpentine in Cecil County, Maryland, and, tracing the line north, another serpentine outcrop is found near Easton, Pa. Other outcrops are near Lincoln, New Jersey; Winsted,

Building the Dredi Tubes for the Hell Gate Power House.

*1300 Hayward St., Washington, D. C.

A Virginia Soapstone Quarry. The Sullivan Channelers on the upper floor are cutting vertically, while that on the lower floor, at the right, is undercutting.

A Sullivan Undercutting Channeler at work.

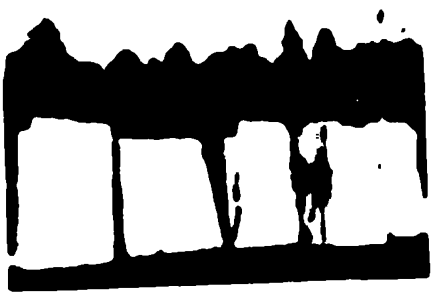
this work, thus freeing the blocks without the damage and waste caused by blasting. The channelers in most general use are of two kinds—undercutters, and swivel-head machines for the vertical cutting. A combination of these two types has recently met with success for opening up new quarries. This is the Sullivan "VX" combined channeler and undercutter, shown on page 151. When undercutting, the channel may be put in within six inches of the top of the rail, and the standard supporting the chopping engine may be set at either end of the frame, to permit cutting out corners. The light weight and blow of this machine is also admirably suited to the uneven floor and soft rock near the surface. The undercut is usually four feet deep.

In a fully opened quarry, however, the "VX" is used for undercutting only, the vertical channels, usually six feet deep, being run by Sullivan size "6½" improved machines, which are preferred by nearly all the soapstone quarrymen in Virginia and Maryland. The channelers are operated by steam from a central power plant. 250 square feet per day is an average performance for the size "6½" channeler, while runs as high as 350 feet have been made. For the "VX" machine 150 to 250 square feet of channel is a day's work, depending on the length of the runs and the hardness of the veins.

The blocks, after being channeled and lifted out of the quarry, are taken to the gang saw, where they are sawed into slabs one and one-half inches thick. They are then cut into the desired sizes, planed, grooved, and finished on the rubbing bed. The necessary pieces are now fitted together, cemented, and securely held by wood screws, the presence of which may never be suspected in a finished laundry tub.

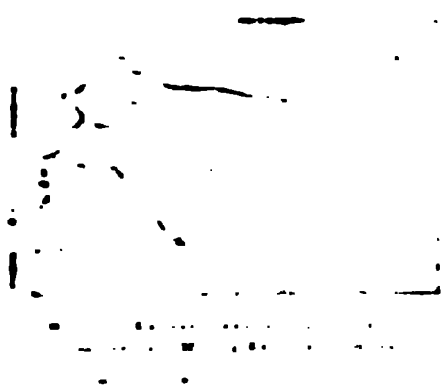
USES OF SOAPSTONE.

Laundry tubs and sinks are the chief forms in which soapstone is put on the market, but with the increase in production of late years has come a corresponding increase in the uses of soapstone. Among the more important of these are slabs for use in electrical work, such as switchboards, barriers, cell-bases, etc.,



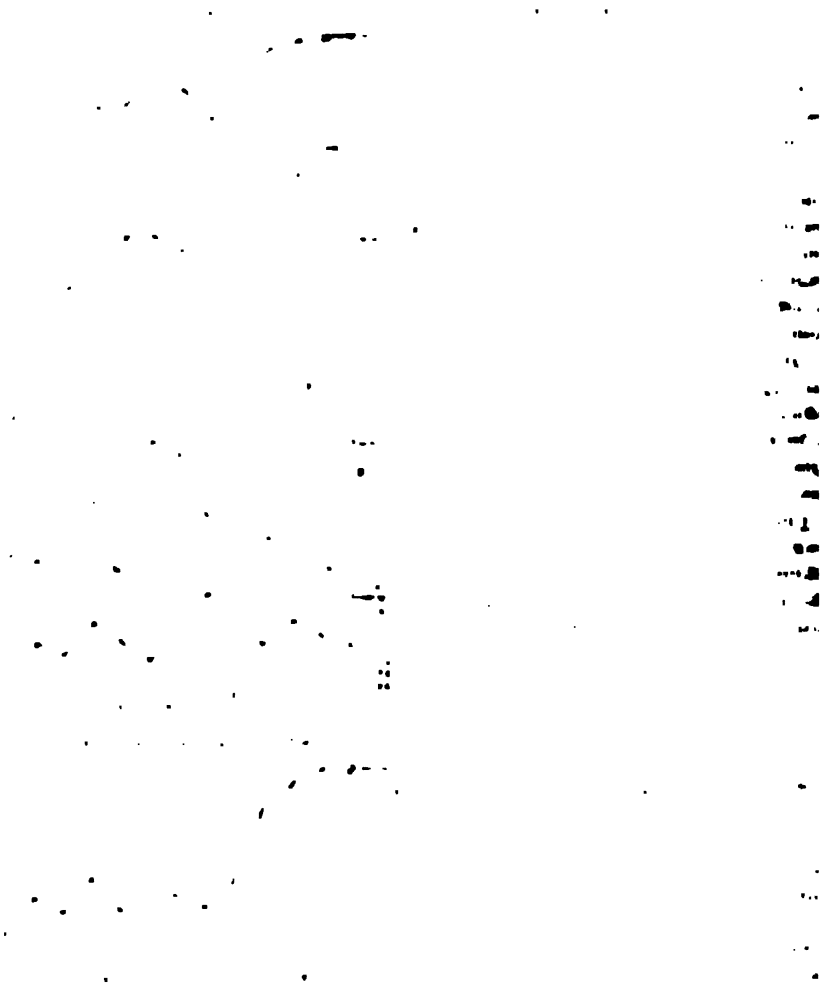
Mining "Sheet Ground" in Southwestern Missouri; a Sullivan Drill at work.

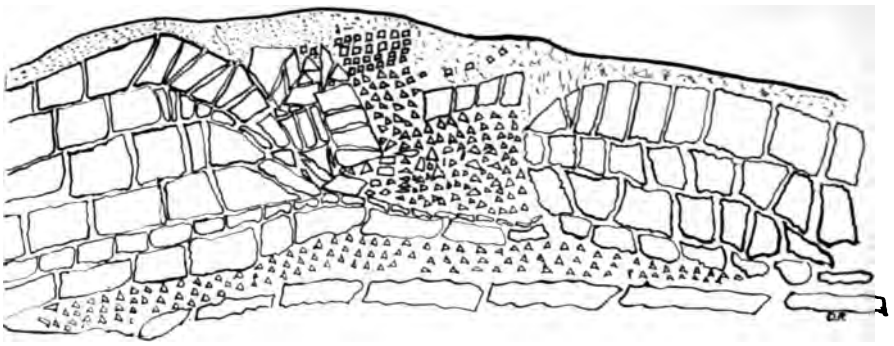
LEAD AND ZINC MINING IN THE JOPLIN FIELD



A Sullivan "Class W F" Duplex Air Compressor at Baxter Springs, Kansas.

Sullivan Drill on tripod, putting in lift holes at foot of a bench of ore. The upper portion of the ore face is visible in the background.





Sections of Typical Ore-Body in Webb City District, Showing Rich Pockety Upper Run with Sheet Ground Below. ◢ Denotes Zinc Blende and ■ Galena.
(By Courtesy of "Mining Reporter," Denver.)

MINING PRACTICE.

In soft ground the ore lies close to the surface and is mined by simple methods. Hand drilling usually serves to break the ground and the workings are heavily timbered to prevent caves.

SHEET GROUND MINING.

The development of the sheet ground is still in its early stages, but has already revolutionized mining methods and has established a new era in the district, prolonging its life indefinitely. The low grade of the ore, compared with that of the soft ground, implies that it must be mined and treated in large quantities and economically in order to show a profit. Heavier machinery and improved processes are therefore being installed, their introduction being further justified by the greater reliability and continuance of these ore deposits.

The usual method of developing sheet ground is by 5x7-foot vertical shafts, which are cribbed for the first 60 or 70 feet. These shafts cost from $15.00 to $25.00 per vertical foot, the cost increasing with depth. Hoisting is by rope and steel bucket, and portable steam hoists of 10 to 25 horsepower, which lift from 750 to 1,500 pounds at a load. The accompanying photograph shows a typical shaft under construction.

Some of the more recent openings have been on the double-compartment plan, with self-dumping skips for handling the ore.

A Sullivan Drill on a long column in a high face of ore.

Shaft of the Columbia Zinc Co., north of Joplin.

Machine drills are employed for shaft sinking, putting in a round of 15 to 20 five-foot holes, depending on the hardness of the ground. When ore is reached the working face is advanced in all directions from the shaft. No timbering is needed, but pillars are left at intervals to support the roof, which is very firm. The face is rarely advanced more than 300 feet from the shaft foot, new shafts being sunk when this stage is reached.

In following the ore lines, the drills are mounted on columns and usually put in a round of five eight- to ten-foot holes, which are shot with 1¼-inch 40 to 50 per cent. dynamite. Fifty feet of holes is considered a good day's drilling (ten hours) for a 3½-inch air drill, and will break 30 to 50 tons of ore. When the ore lens are high, 20 or 25 feet, as frequently occurs, drills mounted on columns drive a heading in the upper part of the stope, and the bench below is lifted by drills on tripods which put in horizontal holes, as illustrated on page 136.

DRILLING MACHINERY.

Drills of all standard makes are in use in the district. The Sullivan machines, those "DC" (2½-inch) and "UW-4" (3½-inch), are preferred by many companies on account of their high drilling speed and low cost for maintenance, as compared with other makes. There are over 1,000 of these drills in the district. Air compressors are largely of the Sullivan class "WB-2" straight line simple steam and two-stage air type, in sizes ranging from 550 to 1,200 cubic feet. There are also a number of belt-driven Sullivan compressors of the straight line two-stage pattern, and a few duplex machines. One of the latter is illustrated on page 136. A Sullivan machine recently developed, which is meeting with favor on account of its high fuel economy and convenience, is the class "WC" straight line tandem compound Corliss two-stage air compressor, illustrated on page 164.

HOISTING PROCESSES.

The ore from the mines is concentrated in jigs, and the tailing upon tables. A complete and well-illustrated article describing the details of Joplin milling practice will be found in the *Engineering and Mining Journal* of July 15, 1907.

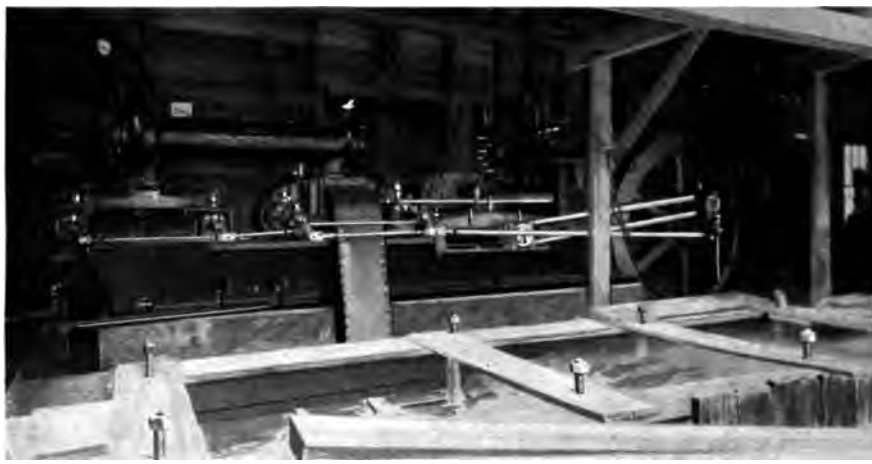
A typical mine and mill.

Allowing for all actual expenses of operation, the preparation of a ton of ore ready for the smelter costs the small operator between $20.00 and $30.00. Royalties, taxes, and all other charges added raise this amount from three to five dollars per ton, but some of the larger companies, who own the source of production as well as concentrating plants, can put the ore in the bin at a total cost of about $15.00 per ton.

In line with the tendency towards economy in operation are the introduction of electrical energy from central water-power plants and the piping of natural gas to the mines from the Kansas fields.

The ore is reduced to metallic zinc and lead by smelters in Kansas, Illinois, and New Jersey.

THE HUDSON RIVER CROSSING OF THE NEW YORK
WATER SUPPLY AQUEDUCT



The Sullivan Air Compressor at Storm-King shaft. The foundation for the second machine is seen in the foreground.

then carried in small cars over a wooden trestle across the tracks of the West Shore Railroad, where it is dumped into cars below. Regular mine cages will soon be installed to take the place of the bucket.

Sullivan "UF-2" (3¼-inch) drills mounted on 5¼-inch single-screw shaft-bars 11 feet long are in use here, and air is supplied by a Sullivan "WB-2" straight line two-stage compressor with a capacity of 1,160 cubic feet per minute.

The shaft on the east shore, at Storm-king, is circular, 17 feet in diameter, and located on a small spur of land between the New York Central tracks and the river. A part of the bank was excavated by open-cut work, so that the collar of the shaft is only a few feet above the water. As at the Cornwall shaft, a steel bucket is used for hoisting purposes, but this also will soon be replaced by cages.

Sullivan "UF-2" (3¼-in.) and "UH" (3⅞-in.) drills mounted on tripods are used here, and air is furnished by a Sullivan compressor of the same size and type as that at the Cornwall shaft. Owing to the formation of the shore, the power plant is located 1,100 feet south of the shaft. Another Sullivan compressor, a duplicate of those already in operation, will soon be installed at this point.

The rock on both sides of the river is a granite, but on the east shore flint occurs in large quantities, making extremely hard drilling. So far, scarcely any water has been encountered, though both shafts are some distance below the level of the river. Indeed, at the Cornwall shaft it was found necessary to pipe water into the shaft to supply the drill runners with a sufficient amount.

The work is going on continuously, night and day, in three shifts of eight hours each. Both shafts will soon be lighted by electricity, the plant on the east shore being already in operation.

When the shafts have reached the desired depth, four Sullivan "B" diamond core drills will be installed—two on either side of the river. Each drill will put in horizontal holes 1,500 feet long, and from the cores taken from these holes the Board of Water Supply engineers will be able to determine exactly the formation of the river bed at all points of the proposed crossing.

A STRAIGHT LINE CORLISS AIR COMPRESSOR.

By H. A. Waldenmaier, M. E.*

All engineers recognize in the Corliss engine the most economical means of compressing air by steam power. In the conventional type, one horsepower may be produced on from 14 to 16 pounds of feed water per hour, when running condensing, or 20 to 25 pounds non-condensing. But the price of the Corliss unit appears large to many operators, even in regions where the cost of the fuel saved would, in a short time, pay for the entire machine. Slide-valve compressors are therefore often installed, which require two to three times as much fuel to do the same work.

The development of an air compressor combining high steam economy with moderate price has advanced but slowly. In some cases the principles of good mechanics have been distorted to the sacrifice of durability, ease of action, and mechanical efficiency, in order to reduce construction costs. In others, various substitutes for the full Corliss valve gear have been offered. It is conceded that some of these compromise machines may fairly claim a certain degree of economy in operation, and that when a test is made under ideal running conditions, they make a good showing as compared with a Corliss compressor.

The conditions of every-day operation, however, are not one time in a hundred like those prevailing in a test. In the latter case, the steam pressure, air pressure, and speed are all constant, whereas in the former the fluctuation in any or all of these factors is likely to be extreme.

Sullivan Drills at Sharon-Ring shaft, on the surface, during a blast.

*1170 West Cuyler St., Chicago.

Sullivan Corliss Straight Line Air Compressor, with tandem compound steam cylinders and two-stage air cylinders.

STEAM REGULATION.

The governor is located on a separate mounting and is a combined speed and pressure regulator. In appearance it is of the Corliss fly-ball type, but it operates in unison with the pressure attachment. Either part may also operate independently of the other when necessary.

The exhaust steam from the high-pressure cylinder is carried around the outside of the cylinder barrel to the top by a passage cast with the cylinder, and discharges into a covered receiver pipe, extending from the top of the high-pressure to the top of the low-pressure cylinder.

AIR EFFICIENCY.

From the standpoint of air efficiency, this compressor takes the same high rank as the class "WB-2" machine. (See illustrations on pages 162 and 167.) The inlet valves on both low-and high-pressure cylinders are of the semi-rotary pattern, positively driven by motion rods from an eccentric pin on the engine fly-wheel. The action of these valves permits the cylinder to fill itself completely at each stroke, with air at the temperature of the atmosphere, and there is no wire-drawing or leakage. The discharge valves are of the automatic poppet type, so arranged as to reduce clearance losses to a minimum. They are removable by hand, together with the valve seats, so that the maintenance of a perfect fit is a simple matter.

The ideal of isothermal compression is closely approximated in these machines by means of unusually adequate cooling apparatus. This consists of heavy water jackets on the air cylinders, and an intercooler of ample proportions, containing copper water tubes, across which the air must pass several times in its course from the intake to the discharge cylinder.

The class "WC" compressor is built very substantially, being self-contained on its heavy frame and on the distance pieces connecting the two steam cylinders. These parts are sufficiently massive to sustain the low-pressure cylinder themselves, without the aid of foundations, if such a necessity should arise.

The straight line type unites with its well-known advantages of engineering excellence the features of low weight, simplicity, and minimum foundations, as compared with duplex machines. These qualities render it possible to sell the class "WC" compressors at a comparatively low price, to transport them readily and at small expense, and to erect them without elaborate and costly foundations at the desired site. They are built at present in sizes ranging from 909 to 2,450 cubic feet of free air per minute.

COAL MINING IN THE INDIAN TERRITORY.

By George W. Blackinton, M. E.*

The Indian Territory coal field lies to the west and southwest of Fort Smith, Arkansas, and is embraced in a circle 100 miles in diameter, of which McAlester is the geographical and mining center. Henryetta on the northwest, Lehigh and Coalgate to the southwest, and Sans Bois and Poteau to the east are the limits of the district.

EXTENT OF THE INDUSTRY.

The industry is comparatively new. Over 75 per cent. of the mines have been opened since 1900, and of these many have, until recently, been worked in only a small way from the outcrop. The following table shows the production by years:

* Missouri Trust Building, St. Louis, Mo.

Rellman Air Compressor Plant of the Heiley-Ola Coal Co., at Heileyville, I. T.

1900	1,360,646	short	tons
1901	2,421,791	"	"
1902	2,820,606	"	"
1903	3,317,388	"	"
1904	3,046,320	"	"
1905	2,970,661	"	"
1906	2,830,430	"	"

...decrease in production during the ...two or three years is attributed to ...competition of oil, used as fuel by the ...roads, manufactories, and other users ...steam in this section. The number and ...ize of the openings (over 100) permit ...uch heavier output if a market were ...ound.

...early all of the openings are slope ...s, although some are worked from ...ts as well. The deepest shafts are ...the Lehigh vein at Coalgate and Le... where there are several over 600 ... deep. The McAlester and lower ...alestine veins near McAlester have ...been sunk at depths of 500 to 550 feet ...the surface. The coal ranges in ...seams from 3½ feet (at Henryetta) ...to feet (at Wilburton), while the aver... age height of vein is from 3½ to 4½ feet. The veins are tilted at angles ranging in various parts of the district from five to 30 degrees. Gas is frequently encountered, but is a serious factor, requiring the use of safety lamps, in only one or two instances.

MINING METHODS.

The coal is mined on the room and pillar system, and hand labor is responsible for more than 95 per cent. of the output, the coal being shot off the solid. It is hauled by mules on the levels, and by small compressed-air haulage engines on the slopes. The practice of "solid shooting" is both dangerous and uneconomical, since it shatters the coal unnecessarily, and when black powder is employed, not infrequently causes windy shots and serious gas explosions. Dynamite is replacing powder in some localities. In driving entries by hand, a cutting two or three feet deep is placed at the center of the working; holes for the cut shots are then drilled 18 inches to

two feet deeper than the cutting and loaded with five or six sticks of dynamite. The resulting explosion is too often more than the roof can safely bear.

MACHINE MINING.

Mining machines are little used, for various reasons. In some mines the heavy pitch of the vein is prohibitive. Electric machines may be used with safety wherever open lamps are employed, but, as a rule, have proved a failure on account of the extra labor required to operate them on the steep inclines. When the pitch exceeds a few degrees, three to four men are needed to handle the ordinary chain breast machine. This was demonstrated several years ago in the Lehigh mines, in which a machine crew consisted of one runner, one shoveler, one man with a crowbar to keep the machine from sliding down hill, and a fourth man to move props, since the machines occupied from ten to twelve feet in front of the coal.

An exception to the rule is found in the Sullivan continuous cutting type, which crosses the entire face under its own power on a feed chain, at one operation. This machine also requires only five or six feet in front of the coal while cutting, so that the third and fourth men are eliminated. It has worked with success in various parts of the Territory on pitches up to 25 degrees, when cutting across the vein, and on pitches of 12 degrees when cutting up the vein.

The machines of this type hitherto used are electric, hence their employment has been restricted to mines in which naked lamps may be carried. The manufacturers, however, are developing an air-driven machine which should find general acceptance in this field.

Pick machines, operated by air, are available for mining in rooms in the Henryetta district, where the vein is flat, and in some of the mines at Wilburton, in which the rooms are driven across the pitch. The general practice in this field, however, is to drive the rooms up the pitch, and under these conditions, pick machine cannot be used to advantage. When the board is placed at the proper angle to enable the operator to handle his machine, a wasteful quantity of coal must be removed to secure an undercut of proper depth.

Sullivan Reversible Steel High-Speed Fan assembled before shipment.

MACHINE ENTRY-DRIVING.

The Sullivan pick machine has, however, been found particularly suitable for driving entries and slopes. Two men operate a machine and drive the entry, air course, and cross-cut, loading out their own coal. The entries are driven seven to nine feet wide and the cross-cuts six or seven feet in width. This enables development to be pushed ahead more rapidly than by hand work. Each place is cut and loaded every shift, moving forward four and one-half to five feet. The men are paid on a tonnage basis, the price being fixed between the machine loading rate (40 cents) and the pick rate (72 cents).

This method of development not only gives the operator better coal from the entries, but does away with heavy shots and the resulting dangers described above. Only a small fraction of the

...ton Sheet Piston, and Tipple of the Hailey-Ola Coal Co., No. 1 Mine, Haileyville, I. T.

...the explosive used in hand ...needed to bring down coal ...d by the machine.

...tem in successful operation ...1 Mine of the Hailey-Ola Coal ...ileyville. The Sullivan "chain ...mmel pick machines are sup- ...ait from two Sullivan 1100- ..."WB-2" straight line two- ...compressors. These machines, ...e illustration on page 167, also ...for the mine pumps in this ...the No. 2 opening, a mile away; ...ting engines at both mines; ...ngine, the box car loader, and ...connected engine for the new ...direct high-speed reversible, ...ting fan (see page 168) being ...No. 2 mine. This last use of ...eliminate the necessity of an ...team plant to run the fan.

...ing practice is trending toward ...ation of high-speed fans, capa- ...ating a higher water gauge ...effectually removing the foul ...d powder fumes from the thin ...veins, as the mines are opened up further.

Machine mining in this field is expected to increase as the mines are developed, and as the miners come to realize that they may secure better pay with less labor and danger by the use of machines than by shooting from the solid. The use of machines in this field will be of two classes, as outlined above, requiring separate and distinct machines. First, the driving of entries and slopes with pick machines; and second, the use in rooms of shuttle and air chain machines of the self-propelling *continuous* cutting pattern.

There should be a good demand for the last named type, owing to its ability to operate on considerable pitches, its safety from gas, and to the fact that many of the operators already have air-power plants installed for other purposes.

The author is indebted to Mr. M. K. McCroskey, superintendent of the Hailey-Ola Coal Company, for the information concerning entry-driving used in this article.

SULLIVAN MINE HOISTS

Sullivan Second-Motion Hoist at the Cliffs Mine, Cleveland Cliffs Iron Mine Co., Ishpeming, Michigan. Drums, 10 feet diameter; Engines, 24 x 48 inches. Non-reversing. Hoisting speed, 1,000 feet per minute.

GEARED PLANTS

are coming into general use in the Lake Superior Iron District, as well as in Arizona, old Mexico, and other Western fields, for mines of moderate depth and tonnage. Their employment for this work results in economy of fuel and lower first cost, as compared with direct-acting hoists, owing to the smaller engine sizes and higher speeds permissible in plants of this character.

Sullivan Geared Hoists are built to meet any requirements of depth, speed, and load. The drums are driven by band friction clutches, or keyed to the shaft, and the engines run continuously in one direction or are reversible, as desired.

Send for specifications for your mine. Catalogue 56-M.

Sullivan Machinery Co.

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MINE AND QVARRY

SVLLIVAN MACHINERY CO.

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J. I. THOMAS

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CHICAGO

[illegible] QUARRY

[illegible] FEBRUARY [illegible]

Sullivan "D-21" Hammer Drill in operation

MINING WITH HAMMER DRILLS

STOPING DRILLS.

The use of air hammer drills in mines is at present confined chiefly to overhead drilling, for which they have shown themselves especially adapted. When flat holes are necessary, or holes from which the cuttings will not fall by gravity, the 2¼-inch piston drill is still the most efficient tool. In nearly all mines, therefore, there is a legitimate field for each machine, and each must be restricted to that field to secure economical results.

OPERATING ADVANTAGES.

The air hammer drill cannot drill a hole of as large diameter as the 2¼-inch piston drill. This necessitates using less powder in each hole, and thus the drilling of more holes to break the rock. Its advantages, however, lie in the ease and rapidity with which it is handled, and in the fact that each hole may be put in in the exact direction and position desired, so that much less powder is needed to cause the rock to break properly. In the case of the piston drill all the holes radiate from a common center, so that more powder is required in some of the holes, simply because they are not in the ideal position for the blast. By means of this drill, narrow veins are opened only sufficiently to permit the drillman to enter. This also gives sufficient room for the operation of the machine. This has been demonstrated in the Cripple Creek district in Colorado, where the veins to be stoped out carry thin values and the neighboring rock is often barren.

DEVELOPMENT OF THE SULLIVAN DRILL.

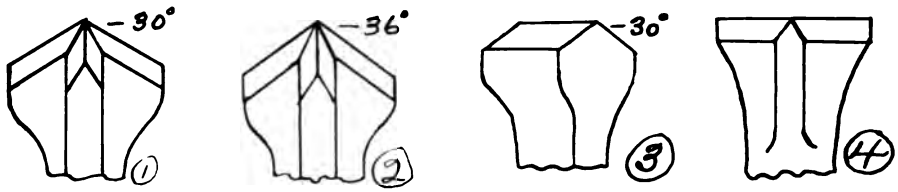
About the time of the production of the first pneumatic hammer mining drill, the Sullivan Machinery Company introduced its "plug hole" drill, mentioned below, into Eastern quarries, for "plug and feather" work in breaking dimension stone. This machine proved to be so far superior to any other machine of the type that a series of experiments was begun to adapt the principles of this drill to the conditions peculiar to mining.

These experiments were very thorough, and were conducted in various western mines, under the most severe conditions to be found. The standard drill, type "D-21," which has been developed as the result, is noteworthy on account of its high drilling speed, its economy of power, and the excellence of its materials and construction, which have reduced repair costs to a minimum.

FEATURES OF THE "D-21" DRILL.

The machine is mounted on a pneumatic cylinder and piston, which form a part of the drill, and serve the double purpose of mounting and of feeding it

Sullivan "D-21" Air-Feed Hammer Drill—For drilling up-holes only for raising and back-stoping.



Shapes of Bits for stoping drill.

TABLE No. 1.

Shape of Bit	Duration of Runs	Diameter of Hole	Average Depth of Hole	Air Pressure	Remarks
30 Degrees					
No. 1.	4 min.	1⅝"	11¼"	94 lbs.	Spots holes easily.
	4 min.	1⅝"	10"	85 lbs.	Easy of rotation.
36 Degrees					
No. 2.	4 min.	1⅝"	8"	94 lbs.	
	4 min.	1⅝"	6"	85 lbs.	
30 Degrees					
No. 3.	4 min.	1⅝"	12"	94 lbs.	Gauge dulled rapidly.
	4 min.	1⅝"	10½"	85 lbs.	
No. 4.	4 min.	1⅝"	11"	94 lbs.	
	4 min.	1⅝"	9¾"	85 lbs.	

AIR CONSUMPTION.

The best air pressure to be used, considering the breakage, wear and tear on machine, as well as efficiency of drilling speed, is in the neighborhood of 90 pounds. The actual air consumption of this type of machine is rather hard to determine accurately, as it is subject to many varying conditions. However, the following figures may be of some service. In the Cripple Creek district in Colorado, where the cost of coal is from $5.00 to $6.00 per ton at the mine, and engineer's wages from $4.00 to $5.00 per shift, custom has established the following schedule of prices charged to leasers buying air namely, $1.50 per drill shift for air hammer mining drills, and $2.50 per drill shift for 2½-inch piston drills. However, in this schedule the cost for air hammer mining drills is comparatively high on account of the greater drilling time in ch shift, because less time is occupied in making set-ups and changing steel. Roughly speaking, the air consumption of the Sullivan "D-21" drill with two-inch cylinder is about one-half that of the Sullivan 2½-inch piston machine.

DRILLING COSTS.

From the date available, it is rather difficult to form any accurate tables for general use, as to the costs of mining with the air hammer mining drill, for the reason that these cost tables are governed entirely by the conditions prevailing in each mine under which the rock must be broken. In order to arrive at any definite conclusions for forming a general table, it would be necessary to gather data covering a large territory and all the conditions of working, (such as labor, cost of power, materials used, kind of rock and formation,) determining the ease with which the rock may be shot, the dimensions to which the stope must be held in

The margin of advantage indicated by these figures for the Sullivan "D-21" drill needs a little emphasis to bring out its proper significance. In the case of the narrow working, the costs per ton show a difference of 10.4 per cent. in favor of this machine over the contesting drill, and of 66 per cent. over hand work. In the wide stope, the cost per ton of rock mined by the "D-21" type is 12.5 per cent. less than that shown by the contesting hammer drill, and 26.9 per cent. below the cost figure for the piston drill. Suppose that a production of 150 tons per shift is desired, and that the workings are of the same average size as that shown in columns 1, 2, and 3 in Table No. 2. If hand miners are employed, the cost per shift will be $586.95, or, for a year of 300 shifts, $176,085.00. If the "contesting drill" is adopted, the cost will aggregate $222.60 per shift, or $66,780.00 for the year. In case, however, Sullivan "D-21" drills are installed, the cost per shift will be $199.50, and per year $59,850.00, a saving of $116,235.00 per annum over hand work, and of $6,930.00 over the "nearest competing" machine. By similar figuring, based on an output of 300 tons per shift, the Sullivan "D-21" drill, in the second working assumed in the table, will show an economy per year of $6,840.00 over the nearest competing air hammer drill, and of $17,450.00 over the piston drill. These figures show the importance of even a slight superiority in working efficiency of the drilling machine.

The economical use of the hammer drill is not confined to stopes of the comparatively narrow widths assumed above. These machines will show results equally favorable in workings of any dimensions, such as the wide "square set" stopes used in the copper mines of Michigan, Arizona, etc., so long as the holes may be drilled at an angle of over 30 degrees with the horizontal, which will permit the dust to fall from the hole by its own weight.

No figures are shown for the piston drill in the narrow stope (columns 1 and 2). On account of the length of the stope to be drilled up to break an equal tonnage, a number of set-ups would have to be made, thus the actual drilling time per shift would be materially cut down, and as a consequence the cost per ton increased.

In a series of competitive tests held in the Cripple Creek district of Colorado, between the Sullivan "Class D-21" air hammer mining drill and other makes of machines, in which the tests in each case were run under like conditions as to air pressure, steel, character of rock, and ability of operator, it was found that the footage drilled in a given time by the Sullivan drill exceeded that of the nearest competitor by an average of about 20 per cent.

TABLE No. III.

Hole	Place	Rock	Air Pressure Pounds	Time Minutes	Inches Drilled by Sullivan D-21	Inches Drilled by Competitor	Sullivan Rate per Minute Inches	Competitor Rate per Min. Inches	Percentage in Favor of Sullivan
1	Mexico	Vesuvianite	75	10	25½	15⅝			
2	"	"	"	15	26⅝	19⅛	(Avg.)		
3	"	"	"	15	28¼	8	2.24	1.29	57.6
4	"	"	"	15	33½	25			
5	"	"	"	17	47¼	25 9/14			
6	Michigan	Jasper Iron Ore	60-65	same	32	16½	——	——	94
7	"	Medium Ore	88	3	54	35	18	12	50
	"	Hard Iron Ore	— —	6	45	18	9	3.6	250
	"	"		9.5	45	29	4.7	3	55

Sullivan "Y" Channeler at work on a long face of Carthage stone.

CARTHAGE LIMESTONE—ITS PRODUCTION AND CHARACTERISTICS

A Sullivan "Y" Channeler putting in a deep cut.

to 12 feet thick, the thickness increasing with depth. The ledges are separated by mud seams, which in some instances have been washed out, leaving hollows and caves of great interest to the geologist. Beds of flint nodules occur at several levels in the formation, but do not occasion large waste, as the stone is usually quarried along them.

PRODUCTION: CHANNELING.

The first step in opening a quarry is to strip the stone of its overburden of soil, flint, and cotton rock, aggregating 6 to 10 feet in depth. When a working floor has been thus established, track channelers are installed, which make parallel cuts from 20 to 30 feet long and 10 feet apart. Cross channels are then run and the key-blocks removed. These blocks are broken away from the quarry bed by wedges driven into the channel cut, assisted by the derrick.

The channelers commonly employed are of the Sullivan single-gang direct-acting type, class "Y," although a few of the double-gang indirect-acting machines are still used for roughing work.

The Sullivan channelers carry their own boilers, thus securing a constant supply of dry steam at 130 to 140 pounds pressure. The bit used, up to a depth of six feet, is composed of three pieces, each 1¼ x 2¼ inches; the outside steels cutting at right angles to the channel, and the center at an angle of 45 degrees. This arrangement permits the cut to be started with a gauge of from 2½ to 3½ inches, which is necessary on account of the depth of the cuts. Below six feet, the ordinary five-piece gang is used. These channelers cut two ledges at one lift, the depth ranging from six to 14 feet (see the photograph above), resulting in increased efficiency in production.

The valve motion employed in these machines allows absolute and instantaneous control of the steam distribution, so as to give a heavy blow or a light tap as required. Carthage stone does not ordinarily show stunned or shattered edges under the channeler blow, but this difficulty sometimes occurs, and many cubic feet of valuable stone have been saved to the producer through the action of this valve. The former practice of considering the quarry bottomed upon the appearance of flint, due to the inability of earlier styles of channelers to cut this rock, was eliminated with the introduction of the hard-hitting Sullivan machines some seven years ago.

CARTHAGE STONE CO., Curtis Wright, President; J. W. Ground, Vice-President; W. R. Logan, Secretary and Treasurer; W. W. Wright, Assistant Secretary; James Logan, General Manager.

CARTHAGE QUARRY CO., Eugene O'Keefe, President; F. W. Steadley, Vice-President; J. E. O'Keefe, Secretary and Treasurer; Martin A. McNerney, General Manager.

SPRING RIVER STONE CO. H. C. Johns, owner and manager.

CARTHAGE BUILDING STONE CO., A. H. Caffee, President; Geo. Allen, Vice-President; Millard Bryan, Secretary, Treasurer, and Superintendent; J. P. Newell, General Manager.

CARTHAGE MARBLE AND WHITE LIME CO., Geo. T. Riddle, President; Fred J. Remmers, Secretary; Henry Hatsfield, of St. Louis, General Agent; R. W. Jay, Superintendent of quarries.

MISSOURI STONE AND CONSTRUCTION CO., N. F. Wright, President and Manager; E. Powers, Vice-President; J. E. Hall, Secretary.

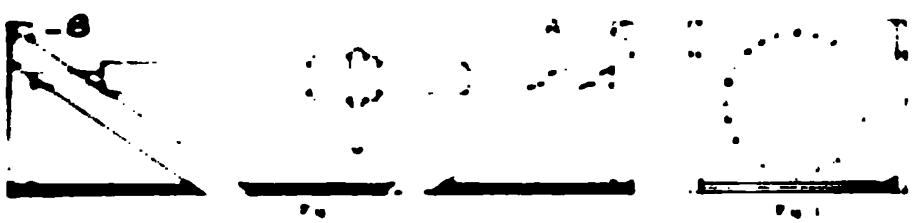
MYERS STONE CO., W. B. Myers, President; Frank M. Myers, Vice-President and Manager.

The demand for Carthage limestone is constantly increasing, and the quarries are kept at their full capacity to supply the market. An innovation of recent date is the introduction of natural gas as a fuel, in some of the quarries.

At Phenix, Missouri, in Greene County, northeast of Carthage, the same grade of white limestone is quarried by similar methods to those employed in the Carthage district. Sullivan "Y" Channelers are largely used. The chief operators in this locality are the Phenix Stone and Lime Co., Messrs. C. R. Hunt, President and General Manager, W. C. Scarritt, Vice-President, and E. H. Jones, Secretary; and the Missouri Crystal Stone Co., Messrs. J. W. Lyman, President, J. H. Blair, Vice-President, H. A. Sutermeister, Secretary and Treasurer, and W. Delarue, Manager of the quarries. Both of these concerns have general offices in Kansas City, Mo. A description of the Phenix quarries will be published in a later number of MINE AND QUARRY.

A Sullivan Channeler in a well-developed quarry. Note the whiteness of the stone.

ADAPTABILITY OF HAMMER DRILLS



Panorama of Ojuela, showing miners' houses, one of the shafts, and

DIAMOND DRILLING AT MAPIMI.

WRITTEN FOR "MINE AND QUARRY"

By J. F. Bennett.*

Mining men naturally think of the Lake Superior iron and copper district as the region of this country where diamond-core drills have been most generally employed for mine exploration and prospecting. Some of the Mexican fields, however, can also furnish examples of consistent, long-continued, and profitable drilling.

Chief among these examples is the work done by the Compania Minera de Peñoles, at Mapimí, in Durango. Mapimí is about 21 kilometers southwest of Bermejillo, with which it is connected by a 30-inch gauge road, owned and operated by the company. It is at the northwestern extremity of the Sierra de la Bufa de Mapimí. Here the precious metals have long been sought, even in the days of Spanish conquest; and the old stopes and workings, the piles of dirt and slag, which mark the site of ancient *haciendas*, remind one of those early times, when quicklime was used for blasting, when the ore was "hoisted" in rawhide *surones* on the backs of *peones*, and packed on burros to the quaint adobe smelters nestling in the valley, under the shadow of the towering peaks, to be treated a few hundred pounds at a time.

But now the visitor finds instead only the locomotive with its shrill whistle, the towering stacks, the great furnaces, and the familiar scenes of a modern metallurgical plant.

The company's general offices, power plant, and reduction works are at Mapimí, but its mines are at Ojuela, 10 kilometers away in the hills. The formation encountered is one which makes diamond drilling an economic necessity. The ore, a silver-lead, occurring as sulphide, oxide and carbonate, is deposited irregularly in pockets of varying dimensions, usually connected by pipes or stringers through the country rock of limestone. The mine is opened by levels from the shaft, and on each level drifts are run at right angles, about 120 meters apart. The territory covered by the mine is thus divided by

El Paso, Texas.

...mit crest. This smelter, at Maquiní, is for to the left, in the valley.

the levels and drifts into cubes. These cubes are carefully probed by diamond-drill holes, run from the drifts, in all directions, to determine the location of the pockets, their size and frequency, and the best points from which to reach them. By this method it is impossible to miss any body of ore of appreciable extent, and at the same time, if ore is not discovered, the expense of drifting is avoided.

The company at present employs 17 diamond drills, and performs about 12,000 feet of core drilling per month. The drill-holes are run at right angles to the drifts, about five meters apart, to an average depth of about 60 meters. Horizontal holes predominate, but there is also considerable angle work.

Four of the machines are of the Sullivan "E" type, which have a capacity of 300 feet in depth and remove a 15/16-inch core. These drills are fitted with longitudinal screw feed with friction compartment, and are operated by electric motors on a 220-volt direct current, which is stepped-down from the 6,600-volt alternating current transmitted from the power plant at Maquiní. The remaining drills are of an early Swedish type. They are run by small electric motors, but the diamond bit is advanced by hand.

The average cost of drilling for the year 1906 for all the drills was about $2.10 (Mex.) per meter. Two Mexicans are employed on each drill, a runner at $2.00 (Mex.) and a helper at $1.25 (Mex.) They average about five meters per 10-hour shift with the Swedish drills and seven meters with the Sullivan "E" machines. The cost of labor only, for the Swedish drills is thus 65 cents (Mex.) per meter, and 46.4 cents for the Sullivan drills.

Owing to the soft, even character of the rock, it is possible to use small carbon, weighing about one karat, of a grade costing $40 gold per karat. The table on page 187 shows the average cost of the company's drilling work for the first five months of 1907. All values are figured in Mexican currency.

The photograph on the following page shows one of the Sullivan drills in operation.

The Compañía Minera de Peñoles is one of the most substantial concerns of the kind in the Republic, and one of the most modern in its methods and equipment, aside from the fact that it has

A Sullivan "R" Electric Diamond Drill in the mines of the Compania Minera de Peñoles, Ojuela, Durango, Mexico.

Ojuela from one of the several shafts. The ore is carried to the cog-road across the suspension bridge.

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NEW YORK, NEW HAVEN & HARTFORD RAILROAD TUNNELS AT PROVIDENCE R I AND TERRYVILLE CONN

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Sullivan Tappet Valve Drills in the heading of the Providence Tunnel.

grade crossings at Pawtucket. It will also bring the Fall River trains into the heart of the city, whereas they now leave passengers fifteen minutes' ride by electric cars from the business section.

The need of better facilities for handling passenger traffic at this point has long been felt, and it was estimated at first that from 125 to 150 trains per day would pass through the tunnel (which is considered about two-thirds or three-quarters of its capacity), with a steady increase until the limit was reached, when it was proposed to build another tunnel of the same size alongside of the one now under construction. On account, however, of the rapidly growing demand for better service, it has now been decided to start work on the second tunnel immediately after the first one is completed.

The tunnel will be about 5,000 feet long by 30 feet wide by 24 feet 5 inches high, cut through rock and lined with concrete. It will accommodate two tracks and will be equipped with trolley wires, as the trains to Fall River are now run by electricity. The through passenger trains will also be hauled through by electric motors, thereby doing away with the smoke difficulties.

The contract for the construction was let in July 1906, to Messrs. McCabe and Bihler of Seattle and Tacoma, Washington, who have had extensive experience in tunnel building in the West, and work was begun in August of the same year. A great deal of preliminary work, such as moving buildings, earth excavation, and the construction of concrete abutments, was necessary before work on the tunnel proper could be started, which, together with the limited space in which to place material for the fill later, made work necessarily very slow; from four

Open cut and portal of East Side Tunnel, showing Steam Shovel at work and method of placing roof and lining.

The concrete for the heading is mixed at the entrance and carried to the inside of the tunnel by means of an overhead rail, which carries the car over the steam shovel without in any way interfering with the work of removal of the bench.

The concrete for the side walls is placed by means of a large form, about 100 feet long, which moves along on a track placed on the floor of the tunnel, about two feet from each wall. This form carries a concrete mixer, driven by a motor, so that the concrete may be discharged directly into the wall, until the form is full on either side, when the form, concrete mixer and all, is removed ahead its own length and the next section put in place.

Work on the tunnel is now progressing rapidly, the heading going forward from nine to 12 feet per day of 20 hours (two shifts of 10 hours each) on each end of the tunnel, while eight lineal feet of concrete arch to the spring line is put in place during the same time at each end. A total of nearly 4,300 feet of heading has been driven, while the work of widening and taking out the bench is following on very closely. It is expected that the headings will meet about April 1, 1908, and that the tunnel will be ready for traffic in September, 1908.

The power plant at each end is equipped with a 900-foot steam-driven air compressor which furnishes power for the concrete mixer, steam shovel, and rock drills.

THE TERRYVILLE, CONNECTICUT, TUNNEL.

As mentioned above, the New York, New Haven & Hartford Road is also making extensive improvements to its line between Bristol and Waterbury, Connecticut, which includes a tunnel near Terryville; the principal object being to do away with the heavy grades which are now encountered, and at the same time reduce the mileage about two miles in 14. Messrs. McCabe & Bihler have a contract here also, being in charge of two sections. Their work covers between five and six miles, including cut and fill work as well as the tunnel through Sylvan hill, which will be about 4,000 feet long.

The work on the cut and fill has been pushed rapidly, and while the work on the latter is particularly heavy, being in some places a matter of 75 feet or more, this is nearly 50 per cent. completed.

Work on the tunnel is carried on in much the same manner as at Providence, but as the improvements at Terryville are not deemed as important as at Prov-

Sullivan Drill on tripod in the Providence Tunnel, drilling the side holes.

Sullivan Two-Stage Air Compressor at the Terryville Tunnel.

tinues, the work is not being pushed as rapidly, and it will probably be the middle of the summer of 1909 before the same is completed. It is planned in the case of the Terryville tunnel to carry the work of the heading, side cuts, and bench along practically together. This tunnel is being worked from one end only, so that the muck may be used in a fill on this end.

The rock encountered here is a granite, as hard as flint in some places. The heading is 12 by 14 feet and the work is done in two shifts, one doing the drilling and shooting and the other the mucking. The average advance per day in the heading is six to eight feet, the best run thus far for two weeks being 78 feet.

The equipment used at this place consists of a straight-line, steam-driven, two-stage air compressor of the Sullivan "Class WB-2" type, capacity 1,100 cubic feet of free air per minute, with a complete outfit of Sullivan UF-3 differential valve drills, which are particularly well adapted to the hard rock.

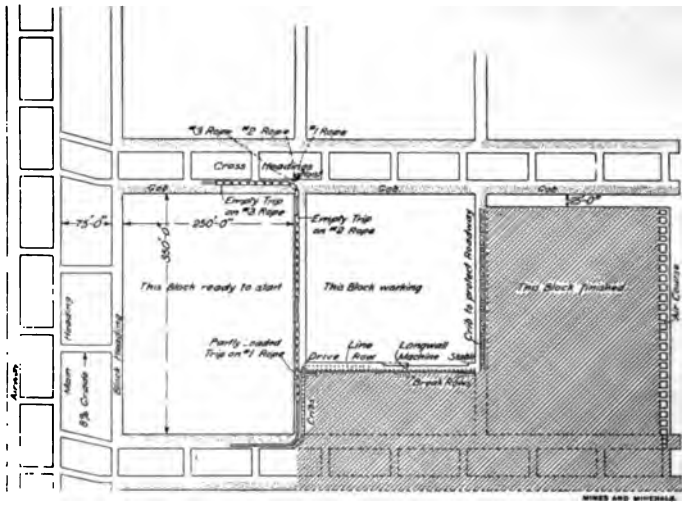
As compared with the West, it is claimed that the East has very little single-track mileage, but it is nevertheless true that there is more double-tracking now under way in New England than has been the case for many years. This not only applies to the N. Y. N. H. & H. R. R., but to the Boston & Albany and Boston & Maine.

The writer is indebted for information contained in this article to Mr. P. H. Haley and Mr. John Haley, superintendents for Messrs. McCabe & Bibby at Providence, R. I., and Terryville, Connecticut, respectively.

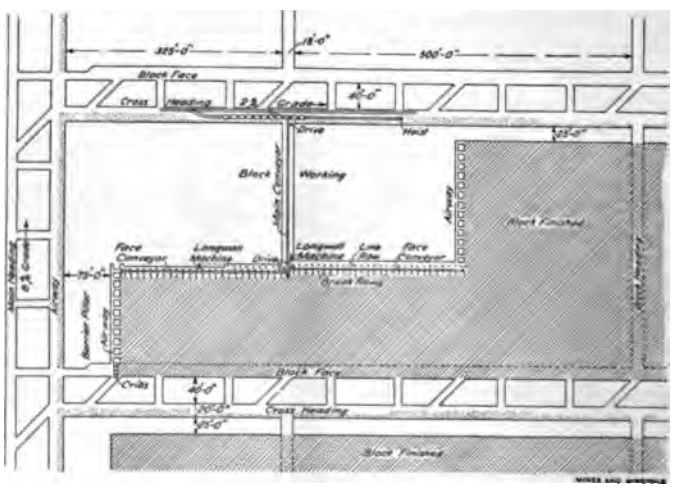
Long-Wall Coal Conveyor.

Face and Heading Conveyors.

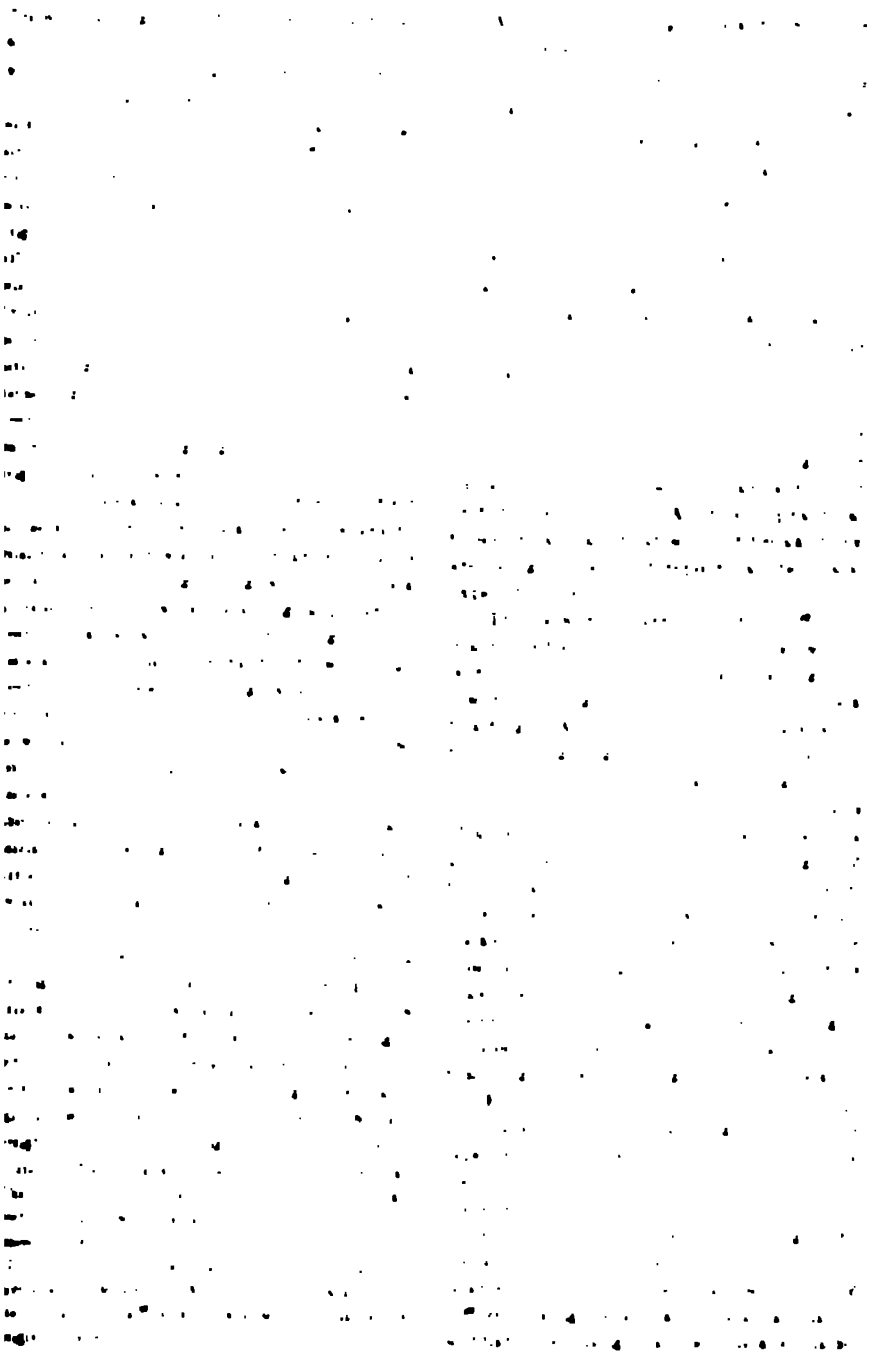
Triple Conveyor System. Face Conveyors to right and left, Heading Conveyor in center.



Plan of workings, Single Long-Wall Conveyor System.



Plan of workings, Triple Long-Wall Conveyor System.



"The cars are handled to the conveyor by means of a double cylinder, with an 8x10-inch double friction-drum hoisting engine. The drums work loose on the shaft independent of each other, and are equipped with a powerful differential brake that will hold any load the engine will hoist; 500 feet of ⅝-inch rope is reeled on each drum. A small hand drum, on which is reeled 150 feet of ½-inch rope, is used to lower the cars around the curve.

"The cars are dropped into the lower heading from the main haulage, and pulled, either with mules or a small engine, to the top of the block heading. Here the rope of the small drum is attached to the coupling between the first and second car, and the cars pushed around the curve. One of the ropes of the hoist is now attached to the rear end of the trip, which is usually ten cars, and the small rope is freed. The trip is then dropped to the conveyor to be loaded. Another trip is attached to the other rope of the hoist in the same manner. This trip is held on the block entry until the first trip is loaded. This having been accomplished, the loaded trip is dropped to the bottom of the block heading and the rope disengaged. The driver here takes the cars and hauls them to the main haulage. The rope is then pulled to the top of the block heading and attached to the cars, as described. In the meantime, the empty trip on the block heading has been dropped to the conveyor and started to be loaded. This change usually occupies two to three minutes. Electric signal-wires are run the length of block headings, by which the head man signals the engine boy.

"The drive, which is a small double-cylinder engine with reduced gearing, is mounted on a frame and attached to the conveyor. The power is transmitted by means of a steel thimble roller chain to the sprocket on the drive shaft of the conveyor.

"The drill used for boring the holes is ingenious tool; the weight of auger and drill does not exceed 20 pounds. The machine is a small four-cylindered air-engine, and has a gear on the crank-shaft that meshes with a gear on the shank of the machine. The auger is attached to a small chuck that is screwed on to the end of the shank. A hose, ⅜ inch in diameter and 50 feet long, attached to the conveyor pipe, furnishes the power for the drill.

"The complement of men required to run a block is 13—i. e., block boss, machine runner and helper, driller, who also acts as shot-firer, engine boy, head man, and six loaders.

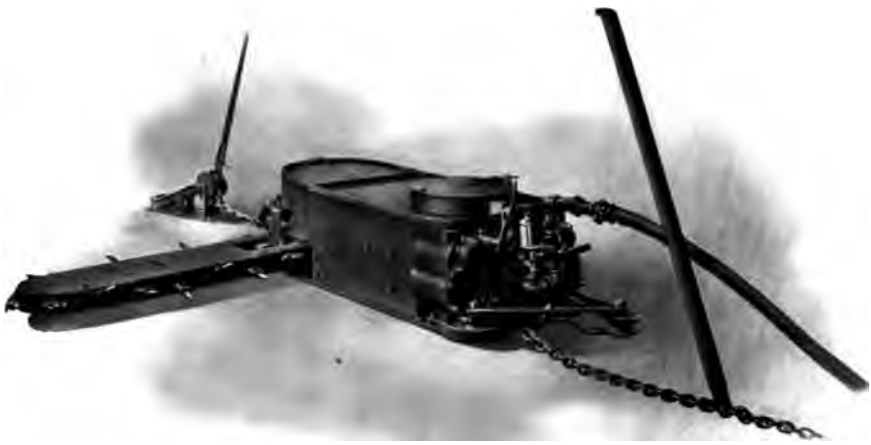
"The 'block boss,' or leader of the crew, has direct charge of the block. He must be a man who has some knowledge of mining and the care of machinery, and possess good executive ability. The balance of the crew, with the possible exception of machine men, are generally non-English-speaking men.

"In preparation for the day's work, the machine has cut one rail (30 feet) on the previous afternoon. In the morning this coal is shot down and the loaders begin work immediately. It requires from 4½ to 5 hours for the machine men to finish the cut. The machine is then overhauled and moved up in position to start the return cut. After finishing their own work, the runner and his helper go back on the block and make preparations for the moving of the conveyor. This consists of setting a line of props, called the line row, about 8 feet apart, and a distance from the conveyor equal to the depth of the undercut. As these are placed the old line row, which is now against the conveyor, is withdrawn. The pulling jacks for moving the conveyor are distributed along the block 40 feet apart and placed in position

"The shot-firer keeps closely after the machine, and is through shooting shortly after the undercut is finished. He then starts from the far end of the block to drill holes in the new face. It usually takes him about two hours to drill the entire width of the block.

Sullivan Electric Long-Wall Machine, class "CH-6," in the mines of the Vinton Colliery Co., Vintondale, Pa.; Machine in position to begin cut from left to right.

Sullivan Long-Wall Machine cutting from left to right. This view shows the machine swung out slightly from the face to avoid an obstruction in the coal.



Sullivan Compressed Air Long-Wall Coal Mining Machine.

the next block and begin cutting. They are followed by the shooter and loaders. The driller sets the line row, and also has time to assist in loading.

"When a block is cleaned up, the timber men move up the conveyor, set the break rows, pull the timber, and make everything ready for the conveyor to start when the opposite block is loaded out.

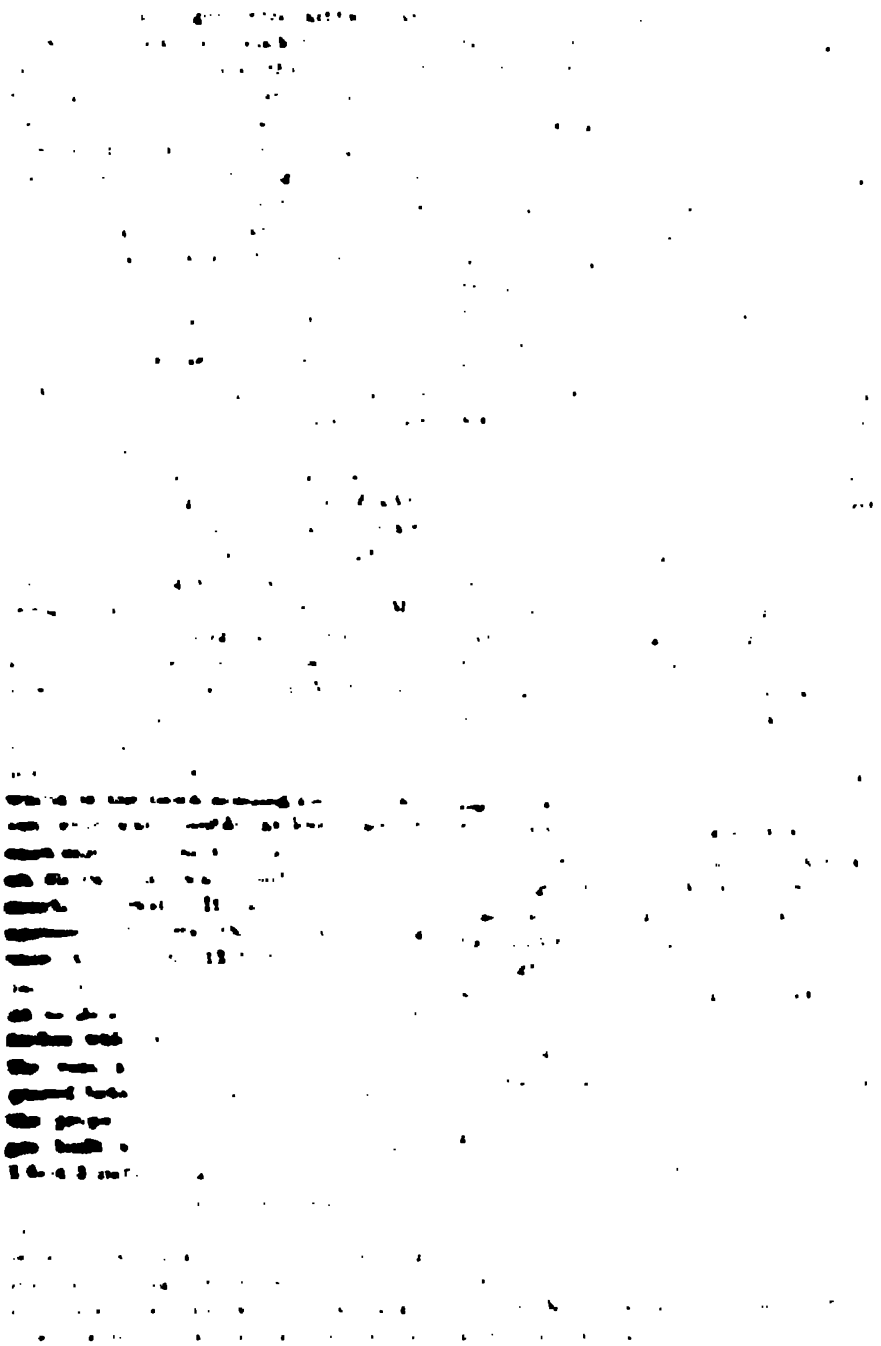
"The main conveyor, which is made up of 12-foot sections, is disjointed about every third day, and one of the sections taken out and moved to the block heading next to be worked. The surplus length of cable is gathered on a reel located at the head end of the main conveyor.

"The working of the face is similar to that of the single block, with the exception that the machine men, loaders, etc., continue at their own special work during the whole shift, the dead-work being taken care of by the four timber men, thus not hindering the steady flow of coal, which averages 150 tons per day.

"For the purpose of keeping the machinery in as good a shape as possible, a skilled mechanic is attached to each mine. He assumes charge in case of an accident and makes necessary repairs, although most of the breakdowns are easily taken care of by the block boss and machine man.

"In the starting of a block is where the best results are obtained, as the roof requires little attention until about 100 feet have been extracted. It then begins to weigh heavy on the posts, and it is found necessary to carry three or four double break rows in anticipation of what is called the 'big break.' This usually occurs when the block is advanced from 100 to 150 feet, although in several instances a 500-foot face has been carried up 200 feet before the overhanging strata broke. After the sand rock is down, only two break rows are carried, and the roof keeps breaking behind the last row as the face is extended.

"The men are paid day wages, and as they become accustomed to the work and machinery are advanced accordingly. The block boss, as an incentive to secure the best results, is paid a small bonus per ton besides his regular day rate



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"SULLIVAN PUNCHERS" have a positive valve motion which secures a powerful blow with slow recovery; economy of air and ease in operation. The results appear in high cutting capacity and low repair costs.

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MINE AND QVARRY

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LOCOMOTIVE THROUGH THE ST. MARYS FALLS CANAL

IMPROVEMENTS IN THE ST. MARYS RIVER

DIAMOND DRILL COSTS

AIR POWER IN A GRANITE QUARRY

SULLIVAN MACHINERY CO.

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W. P. J. DINSMOOR

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THE proper shape for a rock-drill bit, the suitable temper for the steel, and the care and use of drill steel by both blacksmiths and drill runners are important factors in the operation of a machine-drill plant which are often neglected, or which at least do not receive the attention and study needful to secure the best efficiency from the machines.

Theory and practice on these points vary in different localities. While readers may not agree in minor points with the article on this subject printed elsewhere in this issue, it is hoped that the ideas expressed may aid in directing attention to this opportunity for increasing the efficiency of drilling work.

THE use of air power in granite quarries is now too common to excite notice. In fact, it is a small, or an old-fashioned quarry, indeed, that does not boast an air equipment of some sort. But economy in the production of compressed air is another matter, and one which has only within the last two or three years received proper attention in the stone trade. Too often, inefficient machinery has been installed, and the expected economies not being realized, air power has been decried as an expensive luxury. That this is not the case, when proper equipment is selected, is evidenced by the test upon an air plant at a large New England quarry company, which is reported in another column.

MUCH is heard nowadays of the necessity for deep waterways in the interior of this country, to provide transportation for the masses of low class freight which have overburdened the railroads in recent years. Amid the clamor of commercial associations and cities for a "Lakes to Gulf" route, and other enterprises of like importance, which are still much in the future, the public may lose sight of the extensive work actually being done by the government in another quarter.

The St. Mary's River, connecting Lake Superior and Lake Huron, is one of the greatest inland waterways in the world, from the standpoint of the traffic carried. Through it passes the bulk of the iron and copper mined in the Lake Superior district; the grain harvested in Minnesota, the Dakotas and Manitoba, the flour from western mills, and the coal and general merchandise needed to supply these vast districts. In 1897 the freight tonnage carried on the river was about 19,000,000; in 1907, it had risen to 58,217,214 tons, and in that year 20,437 vessel passages through the locks were recorded.

The Government is now busily engaged in extensive improvements, which will not only relieve the present congestion of this commercial thoroughfare, but will provide for all increase in traffic, until the growing draught of vessels again requires the deepening of all channels and locks. The description of a portion of these improvements, given elsewhere in this issue, may be interesting at this time.

The new West Neebish channel; the rock section, 8,800 feet long, with channeled walls.

IMPROVEMENTS IN THE ST. MARY'S RIVER.

SPECIAL CORRESPONDENCE OF "MINE & QUARRY."

Sault Ste. Marie, Mich.)

During the past ten years, the volume of vessel traffic passing through the St. Mary's River, between Lake Superior and Lake Huron, has increased with wonderful rapidity. In 1897 it amounted to 19,000,000 tons. In 1907, it had risen to three times that figure. It may be interesting to note that the entire vessel tonnage entering and clearing from United States ports from and to foreign countries amounted, in 1906, to 54,371,320 tons, or only about 10 millions more than the vessel tonnage of the St. Mary's River alone. The freight tonnage of the Suez Canal, in the same year, was 13,445,504, with a total of 3,975 vessels.

The United States Government has been constantly at work, increasing navigation facilities, but the demand has more than kept pace with these improvements. Seventy-five per cent of the entire traffic of the river is borne by the two American locks, the remainder using the canal on the Canadian side.

Improvements now in progress promise to relieve the present situation materially, and to prevent its recurrence. These improvements include the establishing of a complete double channel 600 feet wide and 21 feet deep from the locks to Lake Huron; the widening of the St. Mary's Falls Canal above the locks, and later, the construction of a third lock. River and Harbor work is also being done elsewhere, which will bring the depth of all channels to the standard of 21 feet.

CHANNEL WORK BELOW THE FALLS.

The St. Mary's River and its various channels are shown in the diagram on page 203. Originally, vessels took the circuitous course outside of Sugar Island and Neebish Island. Several years ago a channel was cut between these two islands, connecting Hay Lake and Little Mud Lake, thereby avoiding the long trip outside of Sugar Island. This channel, called the Middle Neebish, has since carried nearly all the traffic. It has disadvantages, however, due to the presence of several sharp turns, with high wooded banks which render approaching vessels invisible to each other; to the rapid current, requiring down-going boats to maintain a speed of eight to 12 miles an hour for steerage way; and by reason of the length and draft of the newer ore carriers, many of which are over 600 feet

long and draw 19 feet or more of water, necessitating careful handling at the turns.

Boats are frequently delayed, in order to make this passage by daylight, and while deliberate caution has kept the number of accidents low, a material hindrance to traffic has resulted.

THE WEST NEEBISH CHANNEL.

A channel on the west side of Neebish Island, joining Hay Lake and the north end of Mud Lake, has been placed in service this spring to relieve the situation. The north bound traffic still follows the Middle Neebish route, while all south bound vessels use the new West Neebish course. Contracts will soon be let for the straightening and deepening of the Middle Neebish Channel, involving a large amount of submarine rock removal. While this work is in progress, all vessels will take the West Neebish route.

The new cut-off is 13.5 miles long. It will reduce the distance between the lakes and Mud Lake by about two miles. The upper and lower reaches of the channel were excavated in the wet with dredges, the material consisting of sand, marl and clay.

ROCK CHANNEL.

The most difficult part of the work contained in a cut 9000 feet long, and 200 feet wide, which had to be made through solid Niagara limestone, at about the center of the channel's length. The greatest depth of this cut is 28 feet, providing for a minimum depth of 22 feet at low water. The total amount of rock taken out was about 1,200,000 cubic yards. The tenders submitted on this work showed that the expense of excavation by the "dry" method, consisting in laying dam the area by cofferdams and employing open cut practice, would be less than one-half as costly as sub-marine drilling and dredging. The contract was accordingly awarded to McArthur Bros. Co., of Chicago, at $1.36 per cubic yard, on a proposal for excavation "in the dry."

The West Neebish Channel.

(Courtesy of Engineering Record.)

This company sublet the excavation to Grace, Smith & Company of Thetford, Mich., of which Mr. C. H. Locher, an engineer whose high reputation as a rock excavator was established on the Chicago Drainage Canal, is the managing partner. The original contractor agreed to build and maintain the cofferdams.

COFFERDAMS.

Work on the cofferdams was begun in April, 1904. An area about 1000 feet long was first laid bare by constructing two temporary dams across the river, in water from two to seven feet deep. The current ran from three to six miles per hour in this channel. When the water between the dams had been pumped out the excavation of the rock in this section was begun, while the main cofferdams were being constructed at the extremities

The powerhouse and upper cofferdam, West Neebish Channel.

of the portion under contract, in the still water caused by the temporary structures.

These main cofferdams were unusually large affairs. The upper dam was built in water from two to eighteen feet deep, and was 1900 feet long and seven feet wide on top, in its narrowest part. The lower structure was 2600 feet long, 10 feet wide on top and built in water from nothing to 26 feet in depth. The materials used were sandy clay and mud dredged from the channel, and broken rock from the section under excavation. Work on these dams was carried on all winter, in spite of a serious break in the up-stream dam, which flooded the unwatered area. They were completed in April, 1905, at a total cost of about $150,000.

The area between them was unwatered by means of 12 pumps, four of the centrifugal and eight of the ordinary reciprocating plunger type, having a total capacity of 40,000,000 gallons per 24-hour day. The amount of leakage after the first drainage was complete, has been comparatively small.

POWER PLANT.

At the outset it was planned to operate most of the excavating machinery by compressed air. The power plant was installed at the upper end of the work, where a coal supply could be obtained conveniently. This plant consisted of two Corliss cross-compound condensing air compressors, of 4700 and 1900 cubic feet capacity respectively, making the total air power supply, 6600 feet of free air per minute, at 90 pounds gauge pressure. Steam was furnished from suitable boilers at 150 pounds pressure.

An eight-inch main carried the air power along the line of the work, distributing it to the different machines as required. Air reheaters of a special design were used to increase the efficiency of the service. There were 35,000 feet of pipe line of all sizes, entirely exposed to the weather. In winter, fires were maintained at numerous points along the pipe lines, to prevent freezing of the condensation water.

This air supplied about 30 3¼ inch rock drills, used for drilling the blast holes, three eight-inch stone channeling machines, four hammer drills, four cableways, the blacksmith shop, and all except three of the pumps. Each cableway was served by a steam shovel with traction gearing. Some idea of the size and quality of the power plant and equipment

The Steam Channeler (Sullivan Class "F") beginning the West Ninth cut (1894).

may be gained by stating the purchase price, which was about a quarter of a million dollars.

CONSTRUCTION METHOD: CHANNELING.

The rock encountered on this work was hard, compact Niagara limestone. It is very dense, weighing 4,000 pounds to the cubic yard. The walls of the channel are vertical, having been cut out of the solid rock by means of steam channeling machines. Their smooth, uniform faces present a neat, finished appearance, and the flow of the water will be less retarded than if the walls had been drilled and blasted. Vessels will also sustain less damage if they rub the walls, and the latter, being undisturbed by powder, will always remain in their present solid condition.

This work was done with one Sullivan Class "F-8," eight-inch channeler, operated by air power, one Sullivan Class "Y" seven-inch channeler, which carried its own boiler, and two eight-inch air channelers of another make. The three air channelers were equipped with air reheaters. In winter they were provided with board shelters, to protect the operators. These machines are shown at work on pages 203 and 207. The channelers were capable of cutting to a depth of 14 feet, and in most cases put down two lifts. The depth of the cut varied from zero at the ends to 27 feet in the center, with an average depth of 13 or 14 feet. In all, over 200,000 square feet of wall were channeled. An average day's run for the machines was from 75 to 100 feet, although on test runs, the Sullivan machines cut as high as 205 feet.

ROCK DRILLING.

The 3¼-inch rock drills put in holes from 12 to 16 feet deep, at the corners

The West Neebish channel in process of construction. The channel cut may be seen close to the right wall.

of 4x6 foot or 5x5 foot squares. This close arrangement was required by the dense nature of the rock, and made the cost of blasting high. The engineers' records show that about three-quarters of a pound of dynamite, (one-half 60 per cent. and one-half 40 per cent.) was required, per cubic yard. Half of the face of the cut (150 feet) was shot at a time, so that the shovel could remove the muck from one side while the drills were at work on the other.

An average shift's work, both winter and summer, was about 40 to 60 feet of drilling per machine. The holes were charged with dynamite, and fired by electricity. In some cases it was necessary to break up the larger fragments before they could be loaded, and this was done by pop shots, placed in holes drilled by air hammer drills.

STEAM SHOVELS.

The broken rock was loaded into skips by four 60-ton steam shovels, propelled by traction gearing on wheels with 30-inch tires. This is the first case, that has come to the writer's attention, in which traction shovels have been used upon work of this character. The rock, as it stood in place, was frequently intersected by horizontal planes, so that the bottom and benches of the cut were nearly as smooth and level as a ball-room floor. This was particularly advantageous for these shovels, which were rarely stalled by rough or broken ground. The shovels were supplied with boiler feed water by a two-inch pipe line from a pump midway in the cut. These pipe lines, which were from 2000 to 5000 feet long, were laid on the ground, without protection from the weather. They were

blown out each time after use, to prevent freezing, by compressed air, admitted through a one-quarter inch orifice. The air was turned on as soon as the pumps stopped. This plan was so successful that during the two winters only about one day was lost to each shovel, from this cause.

CABLE WAYS.

Each shovel served one of the four cable ways, of which two had a span of 1500 and two 800 feet each. The rock was handled in skips holding six cubic yards; but single fragments containing seven to eight yards, or 18 tons, have been carried without apparent difficulty. An aerial dumping device, invented by Mr. C. H. Lieber, increased the speed with which the spoil was removed.

One of these cable ways has a record of 302,000 yards removed in one month, while the best record for one month for the entire plant consisted in the removal of 466,000 cubic yards of rock.

Retaining walls have been built along both sides of the channel for a distance of 3000 feet. These walls are from five to 20 feet high and five feet thick at the top. They are made of stone taken from the cut, and from small quarries along the work. Their tops are about six feet above extreme low water, or three feet in summer, and will serve as a guide for the vessels using the channel.

CONDUCT OF THE WORK.

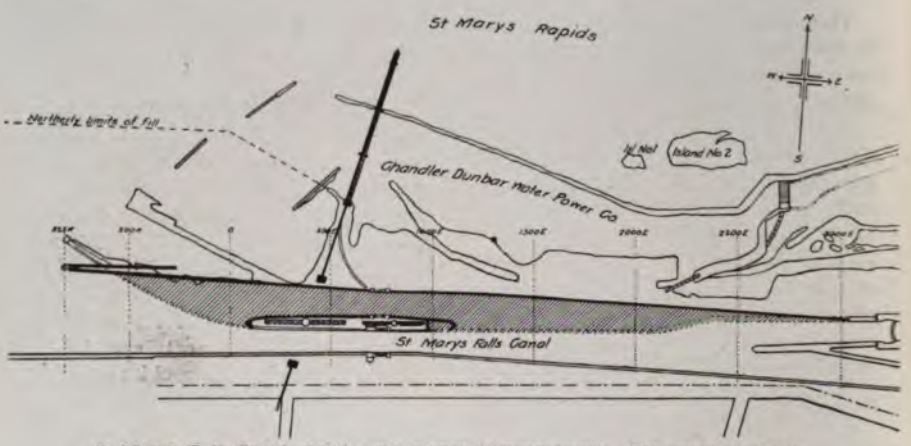
This work was practically finished before the close of navigation last fall. Its early completion, nearly a year ahead of time, reflects great credit on the contractors and their methods and organization. Work has been carried on day and night, practically without interruption, except on Sundays. During 1906, the government engineers credited the contractors with 280 working days. In this climate the winter is six months long, and the thermometer often registers from 10 degrees to 20 degrees below zero, while frequent snow storms keep the ground covered two to three feet on a level.

That work should have been kept up day after day under such conditions indicates uncommon energy and ability. One secret of success in the conduct of this work was the unusually thorough system of inspection, and the high standard of repairs applied to all items of the plant. Special mechanics were detailed to the various classes of the machinery composing the equipment, and prompt attention was given to troubles as soon as they appeared.

Supplies for the three camps and for the power plant were brought 17 miles from Sault Ste. Marie, by boat in summer, and by sleigh, overland in winter.

The improvement of the West Neebish Channel was executed under the direction of Col. C. E. L. B. Davis, corps United States engineers; Mr. L. C. Sabin, Assistant U. S. Engineer with headquarters at Sault Ste. Marie; and Mr. Sutton Van Pelt, in charge under Mr. Sabin. Mr. A. S. Robinson, Sault Ste. Marie, was local manager for MacArthur Bros. Co.

Scribner "S. S." Channeler with air reservoir on the West Neebish cut.



St. Mary's Falls Canal, showing the proposed improvement. The upper approach to the U. S. locks is seen at the right.

ST. MARY'S FALLS CANAL.

On March 5th of this year, the U. S. Government engineers awarded a contract for widening St. Mary's Falls Canal above the locks at Sault Ste. Marie, to the Great Lakes Dredge & Dock Co., of Chicago, on the basis of the following bid:

Dirt excavation and dredging, 135,000 cubic yards at $0.55; rock excavation, 360,000 cubic yards, $1.30; rock channeling, 85,000 square feet $0.30; revetment walls, timber work, 150,000 cubic feet, $0.10; filling above with stone, 20,000 cubic yards, $0.30; concrete, 7,000 yards, $4.00; and special concrete, 9,500 yards, at $5.00 per yard.

The work to be done is shown by the sketch, taken from the specifications, on this page. It consists in excavating and removing material from an area about 3700 feet long, averaging about 125 feet wide and 30 feet deep, and in building about 1400 linear feet of timber crib walls and 3700 linear feet of concrete walls.

The United States has constructed a cofferdam at the upper end of the work, which will permit most of the excavation to be carried on in the dry, the contractor being called upon to furnish and maintain an adequate pumping plant.

The rock material to be removed is largely Potsdam sandstone, some of which is hard, while other portions are soft and seamy. The rock walls will be channeled so as to leave a smooth face. The work also includes constructing timber cribs, filled with stone and concrete revetment walls.

In order to avoid interruption of traffic while this improvement is being made, a rib of rock about 40 feet wide will be left between the present canal and the excavation. This rib is indicated by the dotted line near the lower edge of the section to be excavated, shown on the above sketch.

The government specifications require that both this wall and the new outer wall of the canal shall be channeled, and not drilled and blasted, in order to avoid shattering of the walls, and weakening of the rock behind them. Smooth walls are also required to reduce the danger of injury to vessels, when they come in contact with the walls. The rib above mentioned, together with the connections to the canal proper, will be blasted out during the winter of 1909 and 1910, when the passage is closed to navigation.

The contract requires the contractor to start work within 60 days after having been awarded the contract and to complete the job on or before June 30th, 1910.

Mr. T. C. Lotz, Vice President of the Great Lakes Dredge & Dock Co. will have general charge of the work, being effectively assisted by Mr. Thomas H. Mackie, local manager at Sault Ste. Marie. After careful investigation, the company concluded to operate the channelers by steam and the rock drills by means of compressed air and has closed a contract with the Sullivan Machinery Co. for the following plant:

One 22x14x18 inch duplex belt driven air compressor, Class "WJ". This compressor is of the familiar duplex type with cross compound air cylinders, wherein the air is compressed in two stages with intercooling, thus saving about 15 per cent. in power consumption over simple compression. The main bearings, crosshead, eccentrics, guides and crankends are enclosed in a dirt proof casing. This housing will be partially filled with oil, making the machine self-oiling and thus requiring little attention. The compressor will be driven by belt from a 150 K. W. motor of the synchronous type and will take alternating current at 4000 volts. The electric power will be furnished by the Soo Edison Co., whose new water power plant is near by. A four-inch pipe line will run along the line of work, transmitting power from the air compressor to twelve Sullivan "UF-11" 3¼ (inch) tappet valve rock drills, mounted on tripods.

Sullivan channelers were selected for the work by reason of their showing at the West Neebish cut, described above.

The contractor's equipment also includes two steam shovels, which are already at work, stripping the seven to nine feet of earth which overlies the rock; four dinkey locomotives, and a large number of dump cars.

The power plant will be installed within the next 60 days, and drilling and channeling will begin about August first.

DETROIT RIVER WORK.

A second channel, for down-going traffic, is also being excavated in the Detroit River, across a bend in the stream, now consisting mainly of swamp land. This somewhat resembles the West Neebish work, consisting of a channeled rock section in the center, with earth sections, to be excavated by dredges in the wet, at either end.

Messrs. Grant, Smith & Co. have secured the contract for the dry section and have moved their air compressor plant, drills, channelers and steam shovels to this new location, from Thorne, Michigan.

We are indebted to Mr. Sutton Van Pelt, U. S. Corps of Engineers, for photographs and information used in this article. Acknowledgment for assistance in its preparation is also tendered to Mr. C. H. Lochar, of Grant, Smith & Co., and to the *Engineering Record*, of New York.

Two-stage Duplex Belt-driven Compressor, Class "WJ."

THE COST OF DIAMOND DRILLING IN BRITISH COLUMBIA.*

Two years ago I contributed to the Institute a paper on the results of diamond drilling as carried on at the mines of the British Columbia Copper Company, Limited, during 1905. That paper gave some details as to costs, and the period covered was but 8½ months. Since that year drilling has been carried on more or less continuously in the mines of the company, and the results of this work, so far as progress and costs are concerned, are given in detail in the following tables.

The Progress Table gives the monthly results of work as well as the yearly totals. It is of course important to know the general character of the rock drilled in order to institute comparisons with other localities. In the narrow limits of this table it is not possible to give details as to rocks, but as nearly as possible the rocks comprise diorites, compact garnetites and certain very hard and silicious eruptives occurring in Summit camp. The medium hard rocks include all ores, and, in Deadwood camp, much of the greenstone country. The soft rocks are the limestones, porphyries and serpentines. Of all rocks drilled the garnetites proved much the most severe in diamond consumption, as is illustrated by the work from May to August, 1907, which was mainly conducted in garnetite with some silicious limestones.

Eight hours constitute a shift underground, and nine hours on the surface. On Sundays no work is done apart from repairs to machinery. In May, 1906, the labor was contracted as an experiment, but was abandoned as being unsatisfactory.

The Cost Table gives details of costs under the four groups of Labor, Power, Repairs, Oils, etc., and diamonds. The employes were, normally, a runner and a setter. Extra help was required at times for blasting places for good set ups, for laying pipe lines, moving plant, etc. In August, 1907, two shifts were employed. In June and July of that year the increase in labor costs is mainly on account of the long pipe lines required. The power consumed is taken as being equivalent to that required for a 3¼-in. machine drill, that is to say, about 20 H. P. When drilling at a mine, where for example 15 machines are used on each shift, the diamond drill is charged with 1-31 of the total power costs—it being in this instance run on one shift only.

A Sullivan Diamond Drill drilling an upper hole in a British Columbia Mine.

(* NOTE:—A paper read before the Canadian Institute of Mining Engineers at its meeting in Nelson, B. C., January, 1908, by Mr. Frederic Keffer, Engineer of the British Columbia Copper Co., Greenwood, B. C. The substance of Mr. Keffer's previous article was given in "Mine and Quarry" for February, 1907.)

TABLE 11—PRODUCTION STATISTICS

Class	Number of Mines: Operated during year	Number of Mines: Abandoned during year	Number of Mines: Total at end of year	Persons employed during year: Above ground	Persons employed during year: Below ground	Persons employed during year: Total	Number of Shafts	Number of Adits	Total length of Shafts and Adits	Total length of Shafts and Adits: Sunk during year	Chief Products of Mine	Remarks
Coal												
Iron Ore												
Tin												
Copper												
Lead												
Zinc												
Gold												
Silver												
Manganese												
Mica												
Asbestos												
Clay												
Limestone												
Salt												
Other Minerals												
Total												

TABLE 12—ACCIDENTS AT MINES AND QUARRIES

Class	Fatal Accidents: Underground	Fatal Accidents: Surface	Fatal Accidents: Total	Injuries: Underground	Injuries: Surface	Injuries: Total	Number of Mines	Number of Persons Employed	Fatal Accidents per 1,000 persons employed	Total Accidents per 1,000 persons employed
Coal										
Iron Ore										
Tin										
Copper										
Lead										
Zinc										
Gold										
Silver										
Manganese										
Mica										
Asbestos										
Clay										
Limestone										
Salt										
Other Minerals										
Total										

TABLE 13—QUARRIES UNDER THE QUARRIES ACT, 1894

Class	Number of Quarries in Operation	Number of Quarries Abandoned	Number of Persons Employed	Output	Value	Remarks
Granite						
Limestone						
Sandstone						
Slate						
Clay						
Gravel						
Other Stone						
Total						

TABLE 14—QUARRIES UNDER THE QUARRIES ACT, 1894

Class	Number of Quarries in Operation	Number of Quarries Abandoned	Number of Persons Employed	Output	Value	Remarks
Granite						
Limestone						
Sandstone						
Slate						
Clay						
Gravel						
Other Stone						
Total						

SUMMARY—COST 1906-7.

Labor, total cost	$4983.98
Labor, cost per foot	.747
Power, total cost	1641.30
Power, cost per foot	.246
Repairs, Oil, etc., total	695.29
Repairs, Oil, etc., per foot	.105
Diamonds, total carats	59.609
Diamonds, carats per foot	.00893
Diamonds, total cost	4050.37
Diamonds, cost per foot	.607
Total cost of drilling	11370.94
Total cost per foot	1.705

Where steam power is used either directly or through a steam driven air compressor, the costs are much increased. Where, as in some cases, an isolated 24-H. P. boiler was used, the power costs are still higher, as an engineer has to be provided as well as a team to haul wood.

Tools, repairs, etc., include these items as well as all small miscellaneous expenses. The increasing cost of diamonds added materially to the cost per ft. in 1907.

The third table is a summary of the first two, and shows an average cost per ft. for the two years of $1,705. The carats used per ft. are 0.572/64, or in more intelligible decimals, .00893 carats, so that one carat on the average drilled 111.9 ft. All holes over 30 degrees dip are classed as vertical, and ft. per hr. in horizontal holes is about 15 per cent greater than in vertical ones. The average depth of holes is 81.3 ft., and diameter of cores is 15/16 ins.

In comparing these costs with contractors' prices, it must be borne in mind that contractors usually require air (or steam) and water to be piped to the work, and the mine must in addition furnish the air and water free of charge. In the present cost sheets all these items are charged against costs of drilling.

(The following information did not appear in Mr. Keffer's original paper—It is quoted from *Engineering Contracting*.)

The drill runner set and was responsible for the diamonds. He was paid a salary of $175 per month, while two helpers, during the period of time given, received $3.50 per day. Since the decline in the price of copper, helpers are only paid $3.30 per shift. The compressor men receive $4 per day.

Wood for fuel costs from $3.50 to $5 per cord according to locality and difficulty of cutting and hauling. Electric power costs $33 to $40 per horsepower per year according to locality.

This drilling was done with a Beauty drill, of the Bullock type, manufactured by the Sullivan Machinery Co. of Chicago, Ill. This machine has been in service three years and is in excellent condition. Many of the rods bought with the machine are still in service, though naturally the life of the rods is short compared to that of the drill.

The catalog price of this drill with the equipment that is furnished with it is $1,500. This does not include carbons but does include 2 bits ready to have carbons set in them. The shipping weight of this outfit is 1,160 lbs. This drill is adapted both to mine drilling and surface drilling, as it will drill to a depth of 800 ft., making a hole 1 9/16 inches in diameter and giving a 15/16-inch core. It is well adapted to drilling in hard rock.

Mr. Keffer estimates that with proper usage the depreciation on this plant should not exceed 10 per cent per annum. This does not include the cost of carbons which is given in the tables. For depreciation of plant and interest at 6 per cent, a yearly charge of $240 must be added to the costs given in the tables.

Finishing plant and docks of the Rockport Granite Co., Bay View, Mass.

AIR POWER ECONOMY IN A GRANITE QUARRY.

The Rockport Granite Company, at Rockport, Mass., one of the oldest and largest granite firms in the country, has been a user of air power in its quarries and sheds for a number of years, and presents one of the best examples to be found, of intelligent planning and efficient management in its methods and equipment.

This company owns 300 acres at the extremity of Cape Ann, about three miles from Gloucester. It has ten openings or pits in operation, at Rockport, Pigeon Cove and Bay View, and large finishing sheds at Rockport, and at Bay View. There is also a large quarry at Jonesport, Me., from which a handsome red granite is shipped to Rockport for finishing. The company employs over 300 men. Air power has been used for several years at the Rockport quarries and sheds, being furnished by a 1300-foot compressor at the main opening and by two 550-foot compressors at the newer "Farrar" quarry.

BAY VIEW OPERATIONS.

At Bay View, three miles west of Rockport, on the other side of the cape, there are four quarry pits, and the main finishing plant of the company. This plant includes a mill 150 feet long, containing polishing machines, a surfacing machine, a gang saw and a large lathe; and a cutting shed, the enclosed part of which is 240 by 65 feet. This shed is immediately on the water front, adjoining the shipping dock. The stone is handled from the quarry cars to the shed and from the shed to the dock by a locomotive crane.

POWER PLANT.

The company, about a year ago, installed one of the largest air plants in New England, to operate the machinery in these quarries and sheds. It consists of a Sullivan-Corliss cross compound two-stage air compressor of 1600 cubic feet capacity. This machine is illustrated on pages 214 and 218. It is installed on a solid concrete foundation, in a granite power house, shown on page 218.

This plant supplies air to the four quarries and the cutting sheds. It operates six hoisting engines, averaging 7x10 inches in size, a small stationary engine, between 30 and 40 Sullivan "plug" drills several large rock drills, and five pumps in the quarries, and two sullivers, five Sullivan "plug" drills and about a dozen

Sullivan Class "WX" Corliss Air Compressor at the Bay View quarries of the Rockport Granite Co.

hand tools in the shed. The air is distributed from the compressor in a five-inch main 3600 feet long and a four-inch main 1200 feet long. Branch mains of three and 2½ inch diameter aggregate 2750 feet. There are also 1300 feet of 1¼ inch supply pipe, 2000 feet of 1¼ inch, and 1700 feet of one-inch lines.

To secure the greatest possible efficiency from the air, nine reheaters are installed, at various points in the quarries, and one in the shed. Five of these were made by the Rockport Granite Co., in their own machine shops, and five by the Sullivan Machinery Co. They are rated at a capacity of 250 feet of air cubic per minute each.

In equipping this plant, the company spared no pains to establish a working equipment which would permit the production of stone upon the most economical basis possible. Their attention was addressed particularly to the power plant, and the boilers, air compressor and auxiliaries are all of the most efficient type which they could procure. In order to determine the degree of success which they had attained in this object, a test was made, on January 9th and 10th, 1908, to ascertain the commercial economy and efficiency of the air plant. This test was conducted by engineers of the Sullivan Machinery Co., assisted by representatives of the Rockport Granite Co., and of the manufacturer whose instruments were employed in making the test.

THE COMPRESSOR.

The air compressor consists of a Sullivan Corliss Cross Compound condensing steam engine, with two-stage air cylinders. The low pressure air cylinder is placed tandem with the low pressure steam, and the high pressure air cylinder tandem with the high pressure steam cylinder. Its general dimensions are as follows:

High Pressure Steam Cyl.	13 in. diam.
Low Pressure Steam Cyl.	26 in. diam.
Low Pressure Air Cyl.	24 in. diam.
High Pressure Steam Cyl.	13 in. diam.
Length of stroke	36 inches.

Displacement capacity, 1617 cubic feet of free air per minute, at 86 R. P. M., against 100 pounds terminal air pressure. The steam valve motion for both the steam cylinders is of the full Corliss pattern, the automatic cut-off being actuated by dash-pots. The engine is governed by a weighted fly-ball governor, whose effect is to hold the engine speed constant as the air pressure varies. It works in unison with an automatic air pressure regulator, which reduces the speed of the compressor as any desired limit in the pressure is approached. Both the governors operate by lengthening or shortening the cut-off of the compressor.

A steam receiver is situated between the high and low pressure steam cylinders, for reheating and drying the steam in its passage from one to the other. The compressor is operated condensing, a jet condenser and air pump giving the vacuum. The air pump takes its steam from the reheater coil.

Air is admitted to both air cylinders by means of positively operated semi-rotary valves, and discharged through automatic poppet valves in the cylinder heads. Both the cylinder bodies and heads are supplied with water-jackets, to remove the heat of compression. Further cooling is secured by a large receiver intercooler, placed between the low and high pressure cylinders, and by a receiver after cooler through which the air passes on leaving the high pressure cylinder. Drains are provided at the foot of each cooling tank, so that practically all water vapor is removed from the air before it enters the pipe line. This obviates the danger of freezing at the exhaust ports of the drills and other air-driven machinery. The steel cooler shells or bodies contain groups of copper tubes for the circulating water, and baffle plates cause all the air to cross the tubes in thin sheets during its passage.

A general view of one of the quarries.

Sullivan "D-15" Hammer Drills in the Bay View Quarries.

The boiler is of the return tubular type, fitted with an arch protector and a damper regulator. The auxiliaries consist of a duplex outside plunger pot valve steam pump for boiler feed; two duplex steam pumps for the water circulation, through the compressor cylinder jackets, intercooler and aftercooler; a simple steam pump for removing the condensed steam and cooling water from the condenser, and for maintaining the vacuum, and two feed water heaters.

The boiler feed water is drawn from a concrete cistern, which takes its supply from a small brook near the power plant, dammed up to form a permanent reservoir. The feed water passes first through a heater placed between the low pressure steam cylinder of the compressor and the condenser, and then through an auxiliary heater of the same pattern, receiving the exhaust steam from the pumps. A part of the cooling water from the aftercooler and from the intercooler was used as feed water for the boiler in the first and second day's test, respectively.

CONDITIONS OF TEST.

Two separate tests were run, the first on January 9th, and the second on January 10th. During the first day's test, the regular service conditions of speed, pressure and air consumption were observed, while on the second day, a nearly constant speed was maintained. When the compressor was delivering more air than could be used, the surplus was allowed to escape into the atmosphere. The tests were run continuously from 8.30 a. m. until 4.00 p. m. on the first day and from 8.10 a. m. until 4.10 p. m. on the second day. On the second day the speed of the air pump was reduced, as it was found that more cooling water than necessary was being used. This, together with the higher steam pressure and constant speed, accounts for the lower steam consumption on that day.

METHODS EMPLOYED.

All steam and water piping, glands and valves were inspected and made tight before the test, to prevent leakage. The steam pressure on the first day was held nearly constant at 140 pounds, and on the second day at 145 pounds per square inch. Care was used to keep the fires clean and even at all times. Bituminous "run of mine" coal from Cambria County, Pa., was used. Its analysis shows a fuel value of 15,000 British thermal units per pound. All gages, thermometers, calorimeters, indicator springs and other instruments were carefully tested and standardized for this test, and found to be without appreciable error. Eight indicators were used in taking readings, one at each end of each cylinder of the compressor. Revolution counters were attached to the compressor and each of the pumps. Cards were taken every ten minutes, and readings were made from the counters, steam and air pressure gages, and of the temperatures of the air at all stages of its passage through the compressor, and also of that of the cooling water and feed water.

The compressor ran at an average speed of 77.21 revolutions per minute on the first day, and of 78.04 on the second, the piston speed being 602.26 feet and 608.24 respectively. Air was compressed to an average pressure of 92.47 pounds per square inch in the first test and of 100.05 in the second.

RESULTS.

The results of the tests were as follows:

	Jan. 9	Jan. 10
Steam consumption for compressor, per indicated H. P. per hour, pounds	14.36	14.23
Steam consumption for entire plant	18.75	17.95
Coal consumption for entire plant per indicated H. P. per hour, pounds	1.981	1.844

Bay View powerhouse and finishing plant of the Rockport Granite Co.

Low-pressure side of the Sullivan Air Compressor.

Indicated H. P. required to compress 1000 cubic feet of standard free air per hour from atmospheric pressure to 100 pounds gauge pressure per square inch	3.124	
Mechanical efficiency of compressor per cent.	88.4	89.3

The mechanical efficiency of the compressor was, probably decreased three or four per cent., owing to the fact that an improper lubricating oil was used in the steam cylinders, so that the automatic sight feed oilers could not be used. A careful test of the boiler plant showed an evaporation of water per pound of coal actually used, of 10.21 pounds on the first day and 10.03 on the second. The thermal efficiency of the boiler was 66.7 per cent. and 65.8 per cent. on the two days.

COST OF COMPRESSED AIR.

From these tests, the cost of compressing 1000 cubic feet of standard free air, from atmospheric pressure to 100 pounds per square inch (gauge) was calculated to be $.011065. This is based on the total coal consumption and includes the cost of operating the auxiliaries. Lubricating oil and labor are not included in these figures.

PRODUCT.

The stone produced by the company is very hard and holds its color well. It is free from iron, and has a crushing strength of about 22,000 pounds to the inch. It is principally used for building, bridges and heavy granite construction of all kinds. More paving blocks are made here than anywhere else in New England. The Annisquam Red Granite was employed in the Real Estate Trust Co.'s Building, the Siegel-Cooper Building, New York, the Suffolk County Court House, Boston, and the American Baptist Publication Building, Philadelphia. "Bay View Gray" may be seen in the Boston and Baltimore Post Offices, in the eight towers of the Cambridge bridge at Boston, and the Registry of Deeds of Essex County, at Salem, Mass. "Bay View Green" has been effectively used in the columns of the Madison Avenue Presbyterian Church, in New York, and in the Logan Monument, in Chicago. The company is now supplying stone for the Manhattan Anchorage of the Williamsburg Bridge, for the National City Bank building at New York City, and for a large sea wall at the Kittery, Me., Navy Yard. The waste rock is sold as crushed stone.

ROCKPORT QUARRIES.

The main office of the company is in an ivy-covered granite building, at Rockport, on the brow of a hill overlooking to the East, the stone yard where the paving blocks are cut, the finishing shed, and the shipping docks, along the water's edge. The large quarry (see page 216) is about 300 yards to the west. At the Farms quarry, a mile further out on the cape, many improvements are being made. The stone here lies in sheets, permitting blocks of any dimensions to be gotten out very economically.

QUARRY FACILITIES.

Nearly all the product from the quarries is shipped by vessel from the company's three private docks, which have a capacity of 1200 tons each, per day. Ten vessels are owned by the company and a number of others chartered for their exclusive use. The quarries, stone sheds and yards and docks, are connected by about six miles of railroad track, also the property of the company, together with locomotives, cars and locomotive cranes for handling the granite.

The officers of the Rockport Granite Co., are C. Harry Rogers, President, Rockport, Mass., and Chas. S. Rogers, Treasurer and General Manager. The company maintains branch offices at 31 State street, Boston, and 21 Park Row, New York. It is capitalized for $300,000 and was organized in 1864.

THE PROPER SHAPE FOR ROCK DRILL BITS.

WRITTEN FOR "MINE AND QUARRY"

By D. J. O'Rourke.*

Much attention is paid to the mechanical details of drilling machines at the time of their purchase, to secure those which will be most efficient in the amount of power used and in cost for maintenance. Too often, this is as far as the user's interest goes. Having procured a good drill, he does not take steps to secure the very best working efficiency from it.

The question of drill steel, its selection, care, and use, is one which is given far too little attention, and which in many cases is the determining factor as to the economic success of a drilling plant. If the steels are of good materials, carefully made, sharpened and tempered for the work to be done, and if fresh steels are put into use as soon as the gauge begins to wear, the drills will come up to expectations as to speed and efficiency; but if the blacksmith is incompetent and the drill runner careless, the management could better afford to throw out its machines and go back to hand drilling.

THE BLACKSMITH.

The blacksmith's work should be recognized as almost equal in importance to that of the master mechanic at a drilling plant. The best smith is none too good, even if there should not be enough work to justify the wages he may demand. It is cheaper to have a blacksmith and helper idle once in a while than to have two or three drill runners and their helpers standing around watching the drills wearing themselves to pieces, and perhaps helping them along with a sledge hammer, while the drills fail to give results, merely because the bits are not right. There are also other men on the premises shoveling away dollars in the shape of coal, and this too must be taken into account. When it is all summed up, the idle time of the blacksmith and helper is an insignificant item.

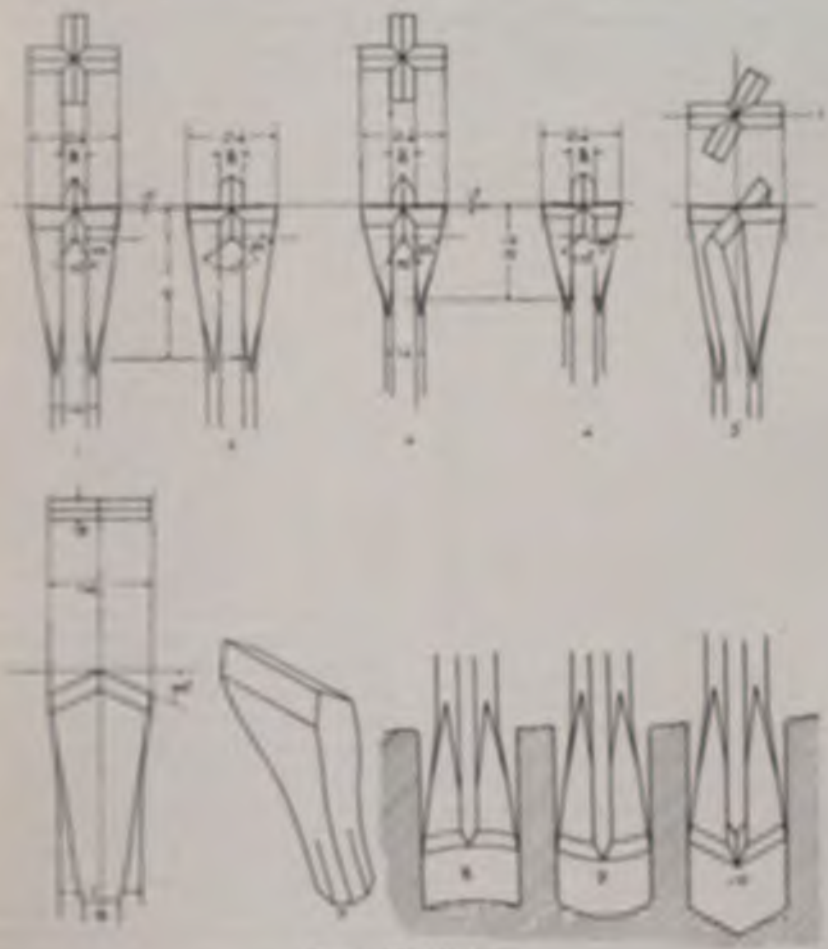
When a new compressor plant is installed, every feature, whereby a pound of coal or an extra foot of air may be saved or made is investigated, and every precaution taken to secure economical results. After the plant is running, the drilling, which was at all times the main object, is sometimes allowed to run along in such a way that anywhere from 10 to 50 per cent. of the power developed is completely lost. No one would think of allowing a hoisting engine to hoist a load with the brakes partially set, but something similar occurs when a rock-drill bit is run so long that it is the same gauge for an inch or more back of its cutting edge, or is allowed to be made with shoulders on it in the first place.

SHAPE OF THE BIT.

For drilling rock of any kind, the cross-bit, made like Figures 1, 2, 3, and 4, sometimes modified to the X shape shown in Figure 5, is usually employed. It will be observed that the bits above referred to are made concave with the corners of the wings ahead of the center. This design is recommended because used bits show very little wear at the center as compared with their outer edges. This indicates that the corners do the largest part of the work. The cutting done by them so weakens the rock toward the center of the hole that it does not afford so much resistance to the center of the bit.

Figures 8, 9, and 10 show what actually takes place in fracturing the rock with bits of several shapes. Figure 8 shows the concave bit, whose corners cut ahead of the center, making the line of breakage very weak and leaving little resistance for the center of the bit, as described above. Figure 9 illustrates a convex bit. In this, the center has to cut ahead of the corners. The fracture line is thus divided, leaving but little work for the corners to

*Claremont, N. H.



Shapes of Rock Drill Bits.

do. The stone shape of the center, together with the increased amount of work which falls upon it, in this case, greatly retards its cutting efficiency. Figure 10, the diamond-pointed bit, also divides the fracture line, but at the same time increases its length, leaving less cutting for the center. With this bit, the rock tends to break to a flatter angle than the angle of the bit, allowing the center to go in advance of the corners for a few blows, when the entire bit again comes in contact with the rock, fracture again takes place, and the process described above is repeated. This bit is recommended only for marble, soft limestone, and other even, soft rocks. Its advantage for this work lies in the fact that nearly all drilling in quarries is done on laid-out lines, so that this form enables the holes to be started accurately. The bit, however, is made very thin and is not strong enough to be satisfactory on general mining and contract work. The flat, or "bull" bit, as it is sometimes called, shown by Figure 7, is made in various shapes, but no matter how it is made its use is very severe on a rock drill. If

thin, it has no reaming qualities; if made heavy, as it generally is, the blow delivered imparts a severe jar to the machine. The flat bit, with diamond point, Figure 6, is a style which has been used in marble quarries from the earliest introduction of the rock drill. The steam pressure used in those days was considerably lower than now, so that this bit was satisfactory, and cut slow enough to ream the holes fairly well. Even under these conditions it was hard on the rotating device, but when higher pressures were introduced its cutting capacity was increased, while its reaming qualities remained the same. The flat bit may cut more rapidly for a short time, but in the long run the cross will be found more economical. The use of the X bit, Figure 5, is not general, but sometimes is desirable when a cross-bit will persist in drilling "rifled" or five-fluted holes on rock of some kinds. Sometimes rifling is charged to the machine, but the fact that the X bit is not required on all kinds of rock rather disproves this imputation.

SHARPENING THE BITS.

Figures 1 and 2 are bits for hard, non-gritty rock, and are alike except for the different angles shown on the cutting edges. Figure 1 shows about the highest angle to which the cutting edge can be made without danger of breaking. The angle shown on the cutting edge in Figure 2 is one of many which may be used under different conditions, without any other change in the bit. In cutting hard and medium hard rock, sharp drills and a wide-open throttle may be used to good advantage, and the hole will not ordinarily clog with mud, as the amount of rock loosened by each blow is so little that it is at once mixed into slush by the water in the hole. The sharp rebound of the drill when striking hard rock, together with the positive recovery of the machine, quickly gets rid of this slush. If the same bits and drill are run on an open throttle in soft or even medium soft ground, the hole soon becomes clogged. The reason for this is that while the hole remains of the same diameter, and the amount of water for mudding purposes is therefore the same, the steel chips out three or four times as much dust at each blow as it does in hard rock. The rate of cutting should therefore be reduced in order to keep the drill working at maximum efficiency. The speed may be regulated by throttling the air or steam, but this reduces the rapidity of action of the drill, so that it does not always mix into slush the dust caused at even the slower speed. The recoil of the steel from soft rock is also considerably less. In soft rock duller bits should be used, like that shown in Figure 4. The angle of the cutting edge may be even higher than this, sometimes almost square on the end, in order to secure good results.

LENGTH OF UP-SET.

In connection with the above subject, it is well to bear in mind the length of the wings or ribs for different kinds of work. Figures 1 and 2 show an extreme length for very hard rock, intended to give strength and hold the gauge as long as it is necessary. Figures 3 and 4 show shorter ribs which give the bit more clearance and make it more desirable for general purposes. Under ordinary conditions its ability to mix mud is much greater than that of the long bit like Figure 1. This shortness gives greater flare to the wings, causing a greater backward thrust to be given the cuttings, whether wet or dry. In rock which wears the gauge rapidly, however, the up-set should be longer. For drilling dry holes in tunnel headings or elsewhere the bit with short ribs has less tendency to allow the hole to draw up. The friction of this style of bit retards the machine but little, and will cause it to cut down toward the lower side of the hole, thereby straightening it. If this is done in time, it saves frequent drops of the arm and keeps the hole where it is wanted. It will be found on experiment that such

results cannot be gotten if a long bit with very slight clearance is used. The wings are five-eighths of an inch thick for the size shown in Figures 1 to 4, and should never be less than that for this size of bit and steel. They should be the same thickness throughout to allow free return of the cuttings. If gauge less than two and one-quarter inches is desired, make the bit correspondingly shorter.

GAUGE.

It should be especially noted that in all the sketches the outer edges of the wings are square. This feature is very important, to preserve the gauge of the hole. Whether the bits are sharpened by machine or by hand, care should be taken that no bits are made with the outside edges made rounding like a figure 8. The question of maintaining the gauge of the hole throughout its length is very important. It should be carefully determined just how much work each drill bit will do before the gauge begins to wear. In the hardest rocks a bit is never in condition to use the second time, and from 24 inches to 30 inches, depending on the length of the feed, is all that is ever attempted. Sufficient steel is therefore supplied, so that a sharp set is on hand for each hole. In softer rock and ore it frequently happens that the steel will not become dull even if used on several holes. Drill runners are, therefore, apt to disregard the question of the gauge so long as the cutting edge is sharp. The gauge, however, causes the rub in more than one sense. This is where the rub comes in that retards the work of the drills, shortens their life, consumes power, and increases the repair bills. For example, on this kind of rock a runner is given two sets of sharp steel to drill a required depth. Each set will drill perhaps two holes each without making trouble. About the third hole on which this steel is used the bits stick and there is a constant demand for a hammer or a chuck wrench with which to bust the steel, and if the right point of humor is reached there is no discrimination shown between the steel and drill piston. Here is a drill that worked all right on the first hole, fairly well on the second, and will not work at all on the third. The rock is the same and the drill is the same, but not so the bits. The only sharp bit that can be gotten into that hole must be made specially in the blacksmith shop half a mile away, so the hammering is kept up and the drill finally worked down somehow, taking usually more time than it took to put in the first two.

When the gauge wears so that a new steel is needed in order to insure its following the last, an entirely new set should be used. It makes no difference if one of the bits still appears good, for it is economical not to waste time with it. On any rock on which the cutting edges are not dulled upon the first hole, a system should be devised by the foreman or superintendent to determine how much each bit will do without too much "hammer help." The improvement will be very pronounced. The runner or blacksmith should have nothing to say as to this system. The blacksmith should have rigid instructions to furnish all bits to the exact gauge required, so that the new bits will work freely when placed in the hole. Much time is wasted from the fact that bits are not made exactly to gauge to begin with.

Users of mechanical drill sharpeners are advised to give thought and care to securing the proper dies and dollies to make bits suitable to the conditions under which they are to be used; also that when drills are being drilled the dies do not open. Some rather impossible-looking bits are occasionally seen for this reason alone.

TEMPER.

The matter of tempering bits is another point in which the blacksmith can save or waste much drilling time to his employers. A competent blacksmith will furnish bits of the precise temper, to suit the rock being drilled.

Duty on Diamond Drill Carbon.

The extensive use of Diamond Prospecting Core Drills in the United States renders of especial interest to the mining industry, a case now before the New York customs officials, for decision. Until about a year ago, black diamonds for diamond drilling and other commercial uses were admitted to this country, duty free, being classed as uncut stones for mining and industrial purposes.

The customs officials now in office at New York have decided, however, that while black diamonds in the natural or unbroken state, may be admitted free, stones split abroad are by this process, rendered more valuable and are therefore subject to duty. A tariff of 10 per cent *ad valorem* has, for the past twelve months, been in force on this class of carbon. This duty enables the carbon dealers to charge at least 10 per cent more for carbon than would otherwise be the case, thereby materially increasing the cost of diamond drill work to the consumer.

The Sullivan Machinery Company, which is the largest manufacturer of Diamond Drills, and also a large operator of these machines, for contract drilling, is one of the heaviest buyers of carbon from dealers in New York, London and Paris. It demands stones of the highest grade, not only for its individual use, but for that of its customers, many of whom prefer to trust to its knowledge and experience in the selection of stones, rather than to buy direct from dealers. This company, in the interest of all users of diamond drills, as well as in its own, has recently registered a protest against this tariff. A test case, involving the payment of duty on a parcel of broken stones from England, was brought before the appraiser in New York City about ten weeks ago. The plaintiff demonstrated that black diamonds were a natural product, not found or produced in the United States, but only discovered in a certain part of Brazil, consequently that the tariff could not be justified on the ground of protecting an American industry; also that unbroken stones were of no value whatever for drilling until reduced by splitting to suitable sizes; and that for this reason, broken stones were no more valuable than unsplit carbon of proper size for immediate use, which are now, and always have been, admitted free. It was also shown that original parcels, containing both natural and broken diamonds are sold in Europe to American importers at a flat price, whether they are suitable for use with or without splitting.

The customs officials endeavored to show, by the evidence of New York carbon dealers, that broken stones command a higher price in this country than the natural variety, but no specific instances were brought out in which split stones had been sold or quoted at a higher price than natural stones of the same weight and quality. On the other hand, letters from these New York dealers were placed in evidence by the plaintiff, in which the same quotation had been made on both classes of carbon shipped mixed together in the same parcel.

The plaintiff made a strong point of the fact that the tariff was of no value to any concern or industry in the United States, but was rather a burden and a restriction upon the entire mining industry. Mexico and Canada have always admitted carbon free, under the name of "Miner's Diamonds" and in the case of Canada, Diamond Drills are admitted free, the Government holding that they perform a valuable office in the development of the mineral resources of that country, while nearly every other class of mining machinery manufactured in the United States is assessed 27½ per cent. *ad valorem* for entry into Canada.

The test case above referred to, is now under consideration by the Board of Appraisers and it is hoped that their decision, which is expected shortly, will result in revoking the duty on black diamonds.

Powerhouse, camp, and western approach to the new tunnel.

THE SECOND RATON HILL TUNNEL OF THE ATCHISON, TOPEKA & SANTA FE RAILWAY.

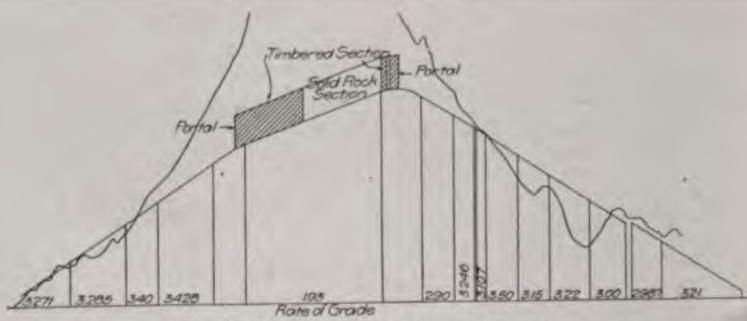
WRITTEN FOR "MINE AND QUARRY" BY W. F. J. HENRICHS.*

The highest point on the main line of the Atchison, Topeka & Santa Fe Ry. is at Raton Pass, on the state line between Colorado and New Mexico, where an elevation of 7,608 feet above the sea level is reached. The steep grades required to ascend to the pass from both sides present a very great handicap in hauling the tremendous volume of through traffic that is carried over this railroad. Trinidad, Colo., is only 15 miles by the railroad from Raton Pass, but the difference in elevation between the two is about 7,000 feet, the tracks rising on a practically uninterrupted grade between the two points. The first ten miles of this ascent is less abrupt than the remainder, as a grade of 184 feet to the mile is maintained in the last five miles. The rise required to reach the pass from the west is about seven miles long and involves an ascent of 991 feet, although steep grades occur for some 10 miles farther.

When the line was first built through Raton Pass it crossed the latter on a switchback. This was replaced about 30 years ago, by the present tunnel, which is 2037.5 feet long, with its west portal at the summit of the grade. This is a single track tunnel, although the tracks both east and westward from the pass are double.

The congestion of main line traffic on the grade, arising from this fact, caused the railway company to undertake the construction of a second single track tunnel in February, 1907. This tunnel will be opened to traffic in the course of a few weeks, and will be used exclusively for west-bound trains. There were two important reasons for driving a new single track tunnel rather than enlarging the

* Engineer, Colo.



Profile of old tunnel and track on either side.

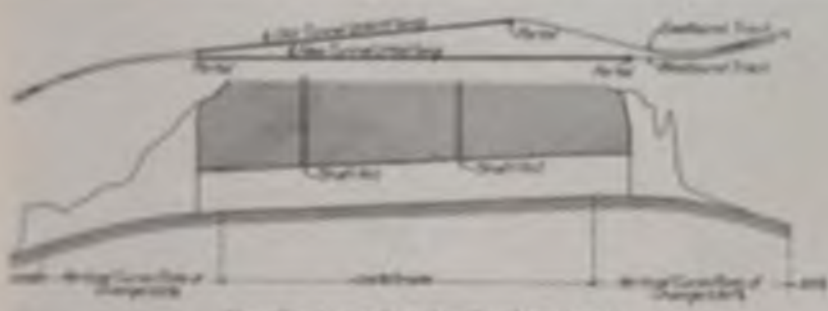
old one. First, traffic can be maintained at all times without interruption while the new tunnel is building. Second, the new tunnel is so located that the grade through it will be only 0.5 per cent, instead of 1.93 per cent, as in the old tunnel. This will permit west bound trains to cut off their helper engines, of which from one to three are needed, before entering the tunnel, instead of requiring their assistance through to the west portal, as at present. The sketches show the plan and profiles of the two tunnels.

PHYSICAL DETAILS.

The new tunnel will be 2,790 feet in length from portal to portal. The two tunnels are close together, their east portals starting at the same point. At these portals their center lines are 40 feet apart. Both tunnels are on tangent for their entire length, their center lines making an angle of about 5½ degrees, so at the west portal of the old tunnel they are 238 feet apart, although the west portal of the new tunnel is 752.5 feet beyond that point. The present track curves around the hill at the west end of the old tunnel and 800 feet beyond the west portal of the new tunnel joins the track that will be laid through the latter.

The new tunnel is to have a cross-section of unusual size, as may be seen from one of the accompanying illustrations, page 228A, and is to be lined from portal to portal with concrete. Above a point slightly below the spring line of the arch, the material encountered is a close-grained hard sandstone. Below this point is a three-foot vein of soft coal underlain by coal shales. The old tunnel is through practically the same material and is only timbered for about half of its length, part of the timbering being at each end. Experience with falls in the unlined solid-rock section of this tunnel, however, has led to the decision to line the new tunnel throughout. The clear height inside the lining will be 24 feet above the top of the rail, at the center line of the arch, and the clear width at the springing line of the arch, 17 feet.

In driving the new tunnel through soft material the excavation is made to a minimum width of 22 feet and a minimum height of 29 feet at the center line. In such material the side walls of the concrete lining have a footing course three feet wide and 1.5 feet high, the rear of which is flush with the rear face of the wall. The latter varies in thickness from 2.5 feet at the base to two feet at the springing line of the arch, the rear face being vertical and the front face battered six inches in 16.5 feet. The arch ring also has a thickness of two feet. Where loose material and rock are encountered the tunnel is driven to a minimum width of 21 feet and a clear height of 28.5 feet at the center line. The side walls of the lining in such material have a 1.5x2.5 feet footing course, are two feet thick at



Plan of both tunnels and profile of new tunnel.

tie bars and 1.5 feet thick at the springing line of the arch; the ring of the latter is 1.5 feet thick. These various dimensions of the concrete lining are for minimum sections. The irregularities between the excavation and the outside limits of the concrete are filled with loose stone packing, laid by hand.

Very little water was encountered in driving the tunnel, so no special provisions had to be made to carry away the seepage.

Such inflow as does occur, however, will be taken to the east portal by a gutter formed in the top of the footing courses of the walls. Refuge bays for switchmen and trackmen working in the tunnel are provided at intervals of 232 feet. These bays are to be placed alternately on both sides of the tunnel. They are simply arched openings five feet wide and 7.5 feet high at the center, in the side walls. These larger openings for placing small push cars are to be built in the side walls. These openings are eight feet wide and 12 feet high at the center, and are spaced 696.5 feet apart.

CONSTRUCTION.

In constructing this tunnel the customary method was employed of driving a heading and then removing the bench. Two construction shafts, five feet, eight inches by ten feet, were sunk to expedite the work, one 1100 feet from the west portal, 180 feet deep, the other 700 feet from the east portal, 125 feet deep. This gave six headings, which were driven at the same time. Steam for both the hoisting engines was supplied by a 100 H. P. boiler set up between the two. The material removed from the headings carried forward from the shafts was hoisted to the surface in 1½ yard dump cars and wasted in adjacent spoil banks.

An approach cut containing about 40,000 cubic yards had to be made at the east portal, and one of 20,000 cubic yards at the west portal. The east cut was made partially in earth and partially in rock and was taken out by hand, the material being hauled away in dump cars. The west cut was largely in rock and was made with a steam shovel.

Three shifts were employed, working eight hours each, and the plan of operation consisted in drilling and shooting a round of holes and loading out the muck resulting from the previous shots, every shift. In hard rock, Sullivan "UF-2" 3½ inch drills on columns were used to do the drilling, but in the coal formation, rotary coal augers were successfully employed.

After the heading had been broken through between the west shaft and the west portal, work was begun upon the bench. The soft material above described was loosened by a few shots from deep drill holes, fired while the rock was still covered with muck from the previous blast. This protected the steam shovel, used for loading out the muck, from damage.

Sullivan "UF-2" Drills in the heading of the second Raton tunnel.

The steam shovel took out 1300 linear feet, involving over 18000 cubic yards of material, in three months. It was then moved to the east portal and started on the bench at that end. Meanwhile the bench adjacent to the west construction shaft, starting at the point where the shovel had been taken out, was removed and loaded into cars by hand, which were taken up the shaft to be dumped. The west 1,100 feet of the tunnel was thus prepared for the concrete lining, work on which was carried on without interference from the unfinished portion of the tunnel excavation.

POWER EQUIPMENT.

The main camp and the main power plant are at the west portal. In the power house are two 80-horse-power tubular boilers, driving a Sullivan Class "WB-2" simple steam and two-stage air straight line air compressor, with a capacity for supplying 12 3¼-inch rock drills; also a 90-horse-power high speed engine belted to two 25-KW, 125 volt generators. These generators furnish current for the electric lights used in the tunnel and shaft and for the ventilating fans, of which there are one at the east portal and one at the east shaft.

The compressor furnishes air to the drills (eight Sullivan 3¼-inch and 22 rotary augers), also to the steam shovel, pumps and blacksmith's forges. The air is distributed by a four-inch air line 3,200 feet long, from the 4½x12 foot receiver at the plant, over the hill through which the tunnel was driven, to the east one of the two shafts, and thence continued as a 2½-inch line to the east portal. A two inch branch was taken from this four-inch line at both of the shafts and carried

down the latter to the face of the excavation on the headings; connections were also carried to the working face of the headings driven from the portals.

The dump cars were handled by two contractor's steam locomotives, fired with coke to prevent excessive smoke in the tunnel. A concrete mixing plant is set up on one side of the west portal approach cut, where rock can be obtained readily for the concrete. A rock crusher is installed just above the mixing plant and delivers to a storage bin over the latter. The concrete is made in a ¼ yard mixer, set on a tower built over the service tracks leading into the tunnel so that concrete can be dumped directly into cars on these tracks. The equipment used in placing the concrete in the tunnel lining forms, consists of a working platform mounted on cars.

PROGRESS.

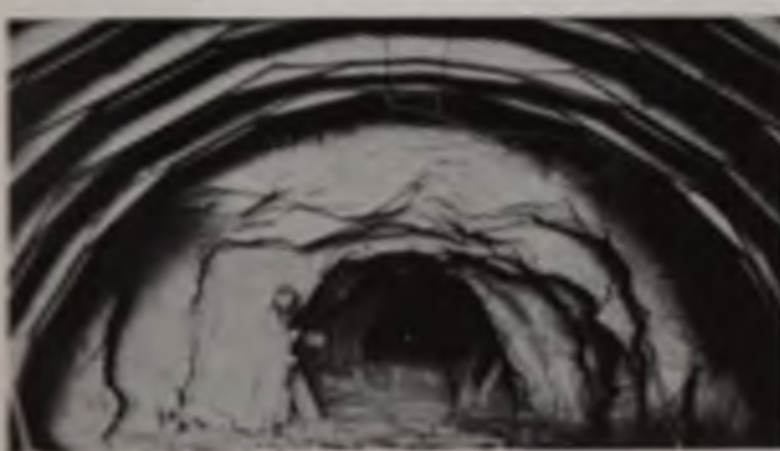
Work on the tunnel has been carried ahead very rapidly in spite of numerous handicaps. The construction camp was established March 22nd, 1907; work was started on the construction shafts April 10th and completed may 15th; the west portal heading was started May 10th and the other five on May 25th, but owing to the scarcity of labor only the portal headings were carried on continuously. The first two headings met July 10th, the second two August 6th, and the last two September 9th. The removal of the bench was finished about January 1st, of this year. The concrete lining was recently completed, and the tunnel will be ready for use in a short time.

RECONSTRUCTION OF OLD TUNNEL.

After the new tunnel has been finished so traffic can be diverted through it, the old tunnel will very probably be enlarged to the same section as the new one and lined from portal to portal with concrete.

The plans for the new tunnel were prepared under the direction of Mr. C. A. Morse, chief engineer of the Atchison, Topeka & Santa Fe Ry., and the construction work is being prosecuted under his supervision by the C. J. Landry Construction Co., of Kansas City. Mr. Jos. Weidel is engineer in charge of the construction work for the railroad company, and Messrs. C. E. Higbee, Theodore Von Borgh and T. M. Broderick, for the contractor.

Acknowledgment is tendered to the *Engineering Record* for some of the illustrations and for a portion of the details given in this article.



Heading and timbering in new tunnel.

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Sullivan Electric Long-Wall Machine at Work.

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MINE AND QVARRY

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MINE AND QUARRY

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An unusual but very practical and economical application of electricity to the operation of coal-mining machines, which might also be profitably adopted for driving rock drills and stone channelers, is exemplified in the power plant at Watsontown, Pa., described in this issue. The electric power, generated in the cheapest possible manner, is carried to local distributing centers, where it is converted into air power, all with the least percentage of loss known to modern practice. This air is led to standard pick machines through short pipe lines, supplying the machines with power at undiminished pressure. By this plan the power is produced under conditions of the highest economy and convenience, and there is no cumbrous or complicated apparatus at the working face. The rapid progress and the convenience of operation secured by the standard air-driven machines are more important factors in the efficiency of mining work than the actual horsepower consumed per machine, without relation to the results gained. Direct or semi-direct electric drive is perhaps economical of power, but its use is attended by slower progress and higher expense for repairs, so that the cost per foot of advance is much larger than if air had been used, in the ordinary way.

MINE AND QUARRY is a medium for the description of new machines, new processes, and of applications of machinery, which will interest the engineers, managers, and mechanical men of ore and coal mines, quarries and contracting enterprises. No charge is made for the paper, but a card is enclosed in each issue, so that readers may acknowledge it, and correct errors in their address. The circulation is a large one. The publishers have no desire to send the paper where it is not read and to individuals not interested in the topics presented.

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ATTENTION is directed to the use of stone channeling machines, described in this issue, for the sole purpose of avoiding the jarring and loosening effect of blasting upon rock walls. In this instance it is important to prevent shattering of the strata in order to minimize leakage beneath a great dam. In other cases, the use of channelers permits excavation lines to be run close to the foundations of buildings and other structures, without danger to them, as in the case of the New York Central sub-grade terminal yards in New York City. In still others, channeling obviates rock slides, which might be caused if the wall were blasted, and makes retaining walls unnecessary. This is one reason why 24 Sullivan Channelers were purchased for the Panama Canal.

A NEW DEPARTURE IN MINE POWER PLANTS.

THE INSTALLATION OF THE COWANSHANNOCK COAL AND COKE CO. AT YATESBORO, PA.

*By Geo. M. Crawford.

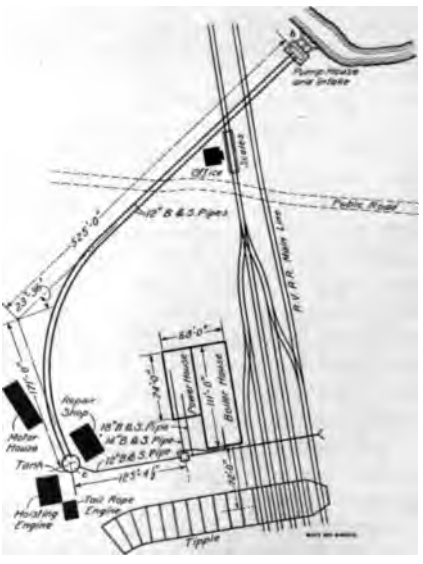
The extension of mining operations over a considerable area of ground is now common in both coal and ore mines. In such instances the generation and transmission of air and electric power assumes new and interesting aspects. The power, which is used for mining machines, pumps, drills, hoisting and haulage, ventilation, etc., may be produced: (1) in several independent plants, each with boilers, generators, and steam- or belt-driven compressors; (2) in a central station, with large economical steam units, the air being piped and the current wired direct to the machines; (3) in a central electric generating plant, from which current is wired to substations, where the air compressors and motors which drive the machinery in each part of the field are located.

The first plan is now seldom adopted, owing to the high cost of supplying fuel and water to each of several plants, and of the duplication of attendants. Further, the system lacks economy and flexibility, because, as the workings are extended, the power lines become longer, more expensive to maintain, and reduce the efficiency of the whole plant. Such a plant can be moved to a new location only at heavy expense for buildings, new machinery, and facilities for transporting supplies.

The second plan is much more convenient and economical in the production of power, but is wasteful in transmission. It requires long air lines of large size and electric wires of large diameter to carry low voltage current suitable for machine operation.

The last plan represents the latest practice, which has been adapted to mining operations from the field of power production for industrial purposes. It involves the production, in a central plant, of high voltage current by steam or hydraulic turbo-generators. This current is then carried to substations, where it operates air compressors, fans, pumps, and haulage locomotives. This results in the greatest possible economy of pipe lines, wiring, attendance, buildings, and supplies. When the workings are extended to the point of "diminishing returns," a new substation may be installed, or the old one moved, at but small expense, and the piping and wires may be used over and over.

Applications of this plan or principle are as yet few in the mining field, and particularly so in that of coal-mining, in which the importance of economy in power production is too often overlooked.



Plan of Yatesboro power plant.
(Courtesy of Mines and Minerals.)

*Pittsburg, Pa.

For this reason the following description of such a power plant will interest mine managers.

The mines of the Cowanshannock Coal and Coke Co., at Yatesboro, Armstrong County, Pa., are midway between Dayton and Kittanning, 24 miles west of Punxsutawney. Shipping facilities are provided by the Rural Valley Railroad, a branch, six miles long, of the Buffalo, Rochester & Pittsburg, with which it connects at Elder. The natural advantages of this location are ideal for mining purposes. The company owns about 19,000 acres of coal land, covering an area about four by nine miles in extent. The coal mined is the Freeport seam, averaging four to 4½ feet in thickness. It is used for both steam and domestic purposes. Being of a strong texture, it is hard to undermine; but when shot, holds together well, so that the proportion of slack is low.

The mines have been worked for about eight years, during which some 1,000 acres of coal have been mined. At this rate, it will be several generations before the property is exhausted, so that a first expense in power-plant installation has abundant time to prove its economy.

METHOD OF OPERATION.

There are now two sets of openings on the property. In both cases the coal is mined from the outcrop on the double-entry system. The main entries run parallel on a slope of from three to five per cent. with 60-foot centers. One is used as the main haulage way, and the other as a main traveling way to the workings. A third entry, parallel to and 60 feet from the others, forms the air course.

Right- and left-hand entries are run at right angles to the slope entries at intervals of 1,000 feet. The cross entries driven from the former are 300 feet apart. Rooms are turned from the cross entries with 50-foot centers, the pillars being 10 feet wide. All entries, room necks, and

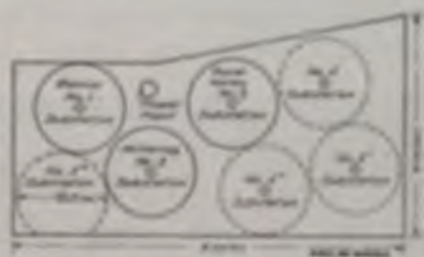


Diagram showing arrangement of substations
(Courtesy of Mines and Minerals.)

breakthroughs or air courses are 12 feet wide. Fifty feet of coal is left on each side of the entries for support. There is a fair slate top above the coal, and strong fire-clay below. The entries are driven 5½ feet high, the top or bottom being removed, as conditions require, to secure proper height. They are laid with 35-pound iron T-rails, while the rooms are equipped with 12 pound iron T-rails, laid on the bottom, without any lifting to increase the height.

MACHINE MINING.

The mines work six days a week, two eight-hour shifts, and produce about 3,500 tons of all grades per day. The coal is mined exclusively with Sullivan Compressed-Air Pick Machines of the Class "S" type. This machine, of which 82 are in use, has a cylinder 5½ inches in diameter, cuts to a depth of 5½ feet, and weighs 825 pounds. The company adopted this make and class of pick machine after an experience of several years with the various machines upon the market, which satisfied its officials as to the superiority of the Sullivan machine, for its conditions in regard to cutting capacity, economy of power and maintenance, and convenience in operation. The Jefferson and Clearfield Coal and Iron Co. and the Rochester and Pittsburg Coal and Iron Co., which are controlled by the same interests as the Cowanshannock Coal and Coke Co., also use Sullivan "Punchers" extensively, owning about

225 machines. One of these machines is shown in operation in No. 1 mine at Vanshura, on page 232.

After the coal is undermined, three holes are drilled in the face to receive one-inch powder. The charge is six to eight inches long. The center is shot first, and after this "tight" shot the two sides or "horse" shots; the latter breaking down the coal which hangs to the rib after the center has been freed.

HAULAGE.

The undermined coal is loaded into cars at the face. The cars are pushed by hand to the cross entries, where they are gathered by six- and eight-ton electric locomotives, hauled to parting or side tracks in the main entries, and thence pulled in large trips to the tipple by 10- and 12-ton electric locomotives. Permanent locomotives of different mines are employed in all.

TIPPLES.

There is a tipple for each set of openings, that for No. 1 mine being shown on this page. Each tipple is equipped with two automatic crane-over dumps. The coal is hauled into railroad cars on one main track and four sidings, so arranged as to permit loading six sizes of coal—viz., run of mine, lump, slack lump, nut, slack, and special mine run. The cars, on being loaded, are run to the railroad scale office, 300 feet below the tipple, weighed, and made up in trains on three 1,300-foot side tracks adjacent to the main line.

VENTILATION.

The mines are ventilated by three large steel-plate fans; one is located near each of the tipples, and the third near the No. 1 power substation, as described later.

LABOR.

The company employs about 1,000 miners underground, who are paid on a tonnage basis. The men live in 225 company houses near the mines.

THE NEW POWER SYSTEM.

During the first six years of operation the power plant consisted of two units, one at each set of openings. These contained tubular boilers, straight-line air compressors for the mining machines and pumps, and electric generators, delivering current at 500 volts, for haulage.

It became apparent, as the mines developed, that several more of these plants would be needed, at widely separated points, to obviate losses in transmission. The high cost of providing fuel and water to these plants made this plan objectionable.

After much deliberation, the company's engineers decided on a plan hitherto not attempted in coal-mine practice—viz., a central power plant, with substations in different parts of the field. This plan involved large expense, and for that reason could be considered only by a company like this, of great financial strength. The plant was to be centrally located, at a point convenient for fuel and water, and was to represent the highest economy in operation. Electrical power was to be distributed at high voltages to the different substations, and then stepped down to proper intensities for haulage, pumping, and the other requirements of operation.

Central power plant and tipple of No. 1 Mine at Vanshura.

Boiler-room, showing Underfeed Stokers and Chutes from coal-storage bin.

This plant was completed about two years ago. It is shown on page 233, while the diagram on page 230 shows its general arrangement and dimensions.

BOILER-ROOM.

The boiler-house, 111 by 37 feet, is shown on page 233. It contains four batteries of water-tube boilers, each consisting of two 500-horsepower units, making a total installation of 4,000 horsepower. The plant is so arranged as to permit an increase to 6,000 horsepower when necessary.

The coal supply (slack) is carried from a 15-ton hopper under the tipple to a steel bin in the boiler-room on a rubber belt conveyor. The bin and conveyor run the full length of the building, and an automatic reversing tripper, running above the bin, distributes the coal evenly. From this bin, which holds 300 tons, the coal passes through spouts with controlling gates to the hoppers on the underfeed stokers. The stokers are run by steam, with automatic devices for controlling the air pressure and quantity of coal delivered to the grates. These appliances hold the steam pressure uniform at about 175 pounds. Ashes are removed in standard railroad cars through a tunnel, running the length of the building, under the concrete ash-pits below the boiler-room floor. The tunnel entrance is shown in the photograph on page 233.

A 12½-foot blower supplies draught to the furnaces. This fan is driven by either one of two horizontal steam engines, one of which is usually held in reserve.

Duplex steam feed pumps, 14 x 8 x 18 inches, also installed in duplicate, furnish

water, which is first heated to 205 degrees by an open-type feed-water heater. This takes its supply from the condenser discharge, exhaust steam from the ventilator being used for heating the water. The water supply for the condenser is pumped from a nearby creek by centrifugal pumps at the rate of 6,000 gallons per minute.

It may be seen from the cut on page 230, taken while the plant was in full operation, that this system secures the whole fuel value from the coal. No smoke issues from the stacks during the exposure of the plate.

These boilers supply steam for a hoisting engine, hoisting engine, and pumps, used for the town water supply, as well as for the turbo-generators.

ENGINE-ROOM

The cut below shows the engine-room, 74 x 35 feet, from the balcony. The main plant consists of two 1,500-KW. turbo-generators, which use saturated steam at 170 pounds pressure, with 26 inches vacuum. They revolve 900 times per minute, and are run night and day, seven days a week, under an average load of 2,500 KW. Sixty-cycle, three-phase, alternating current is generated at 6,600 volts. Each turbine is fitted with a separate jet condenser, located on the first floor. Their tops, connecting with the turbines, may be seen in the cut, at about the floor line of the balcony.

Provision is made for adding two more generating sets when needed. Exciting current for the turbos is supplied by a 75-KW. turbo-generator and by a motor generating set using alternating current at 220 volts. A 300-KW. motor generator set in the basement of the power-house supplies current for haulage in and about the tipple.

A traveling crane in the engine-room provides handling facilities for the heavy machinery. The machinery in the blacksmith, machine, and carpenter shops, which form a part of the main power plant, are driven by electricity.

SUBSTATIONS

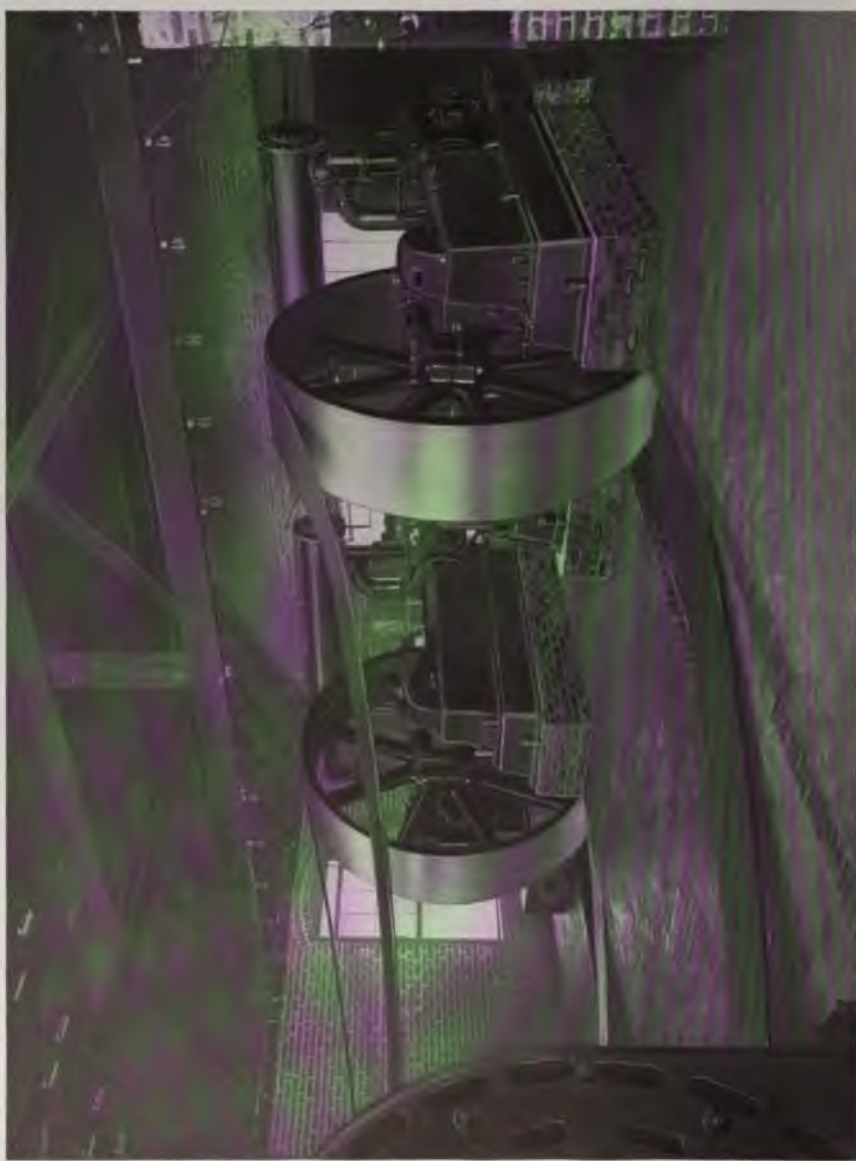
The sketch, page 231, shows the general shape of the company's property. The three solid circles show the three substations already installed and the area served by them, while the dotted circles show locations for future stations, as the development advances. Blanco station, or No. 1, is 8,000 feet south of the power plant; McKelvey, or No. 3, is 10,000 feet to the northeast; and Rural Valley, No. 2, is 12,000 feet northwest.

The current is stepped down by transformers at the substations, and delivered to the haulage systems by rotary converters at 500 volts direct current.

The air compressors for operating coal cutters, pumps, etc., are belted to motors taking alternating current at 6,600 volts. These high-voltage motors were the first of their kind used in this country, and their successful operation shows what can be done without stepping down and converting the current, as is ordinarily thought necessary.

The Blanco station contains one 300-KW. rotary converter and step-down transformers, furnishing direct current at 500 volts for haulage. Three 1,400-foot duplex, belt-driven air compressors

Turbo-Generators in the Central Powerhouse



Sullivan "WJ" Air Compressors in the Rural Valley Station, Cowanshannock Coal and Coke Co., Yatesboro, Pa.

iven each by a 250-horsepower as above described. There is also -horsepower variable speed in- motor of the same type, direct ed by a flexible coupling to a steel fan, which runs at from 90 revolutions, and at full speed sup- 200,000 cubic feet of air against a h water-gage.

air piping and wiring from the station enters the mine through driven to the outcrop.

McKelvey station contains three ompressors of the same capacity as ers, but there are no converters or formers, as power for haulage is not ed from this point. The air mains the mines through the slope, as at Sayre station.

No. 2, or Rural Valley station, con- a converter and transformer, as at , also four air compressors, driven 0-horsepower, 6,000-volt, 60-cycle, -phase, alternating current motors.

SULLIVAN AIR COMPRESSORS.

e photograph on page 236 shows of these compressors, of the Sullivan "WJ," duplex, two-stage type. low-pressure cylinders of these ma- are 24 inches and the high-pres- cylinders 14½ inches in diameter, a common stroke of 18 inches. They ver 1,414 cubic feet of free air per ute at 150 R. P. M.

the design of these machines pains taken to secure the best possible ency. The cylinder bodies and s are water-jacketed, and the air- passages are so arranged as to the water jacket between the in- ng air and the cylinder wall up to point of entrance to the cylinder. intercooler is of unusual area, and air is forced to take a circuitous ge across the cold tubes in its way one cylinder to the other. Moisture ed by the air through the first stage pression is practically all condensed removed in this cooler.

The inlet valves are of the semi-rotary pattern, driven by eccentrics on the shaft. This valve motion and the large diameter of the valves give a very free opening for the air, and quick closing, which insures a full cylinder at each stroke. The valves are so set that air pressure from the cylinder holds them to their seats, minimizing leakage. Automatic poppet discharge valves with removable seats render inspection and care easy. The sectional view of the cylinder, page 238, shows the sleeve arrangement.

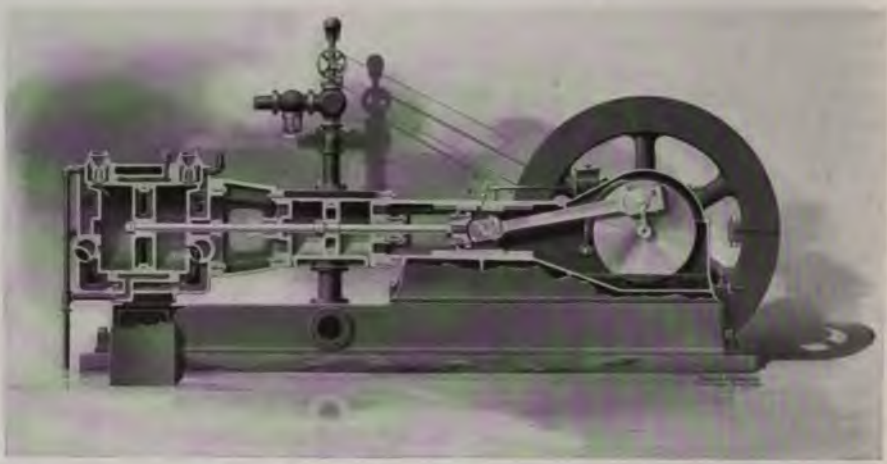
The eccentrics, piston rods, and connecting rods are enclosed in a dust-proof case, and these parts are automatically oiled from tanks in each frame, into which the lower edges of the crank disks dip. These machines are practically automatic. The frames are of the "heavy duty" type, and the whole machine is supported on an iron base to insure correct alignment.

These compressors were constructed especially for this work. As it is contemplated that the substations will be moved from time to time, the base of each machine is cut through the center and bolted together. When the machine is knocked down, any part of it may be hauled by wagon. When being reset, perfect alignment of all parts is provided for by means of dowels.

BORE HOLES.

At the Rural Valley substation the air and electric lines are taken into the mine by means of three bore-holes, one for each form of power, sunk with a churn drill to the bedding, close to the rib.

The holes are 10 inches in diameter. The one for air is cased to bed-rock; inside of the casing runs the eight-inch air main. The space between the pipe and the casing is filled solid with cement from top to bottom, holding the line rigid and preventing it from acid waters. The main runs along the slope entry, and from this



Sectional view of a Sullivan Duplex Self-Oiling Air Compressor (steam-driven). The Air Cylinders, Frame, and Oil Wells on the machines here described are of this type.

the branch pipes are carried to the rooms, where the machines are supplied by 1¼-inch lines.

This system constitutes a large saving in pipe as well as in power economy. As a section of the mine is worked out the pipe is lifted and relaid elsewhere. The short length of the lines permits practically the full capacity of the compressors to be delivered at receiver pressure at the machines, thus securing the best efficiency. Air is also used in all pumps which deliver water to sumps. Electric rotary pumps raise the water from these sumps to the surface.

The two bore-holes for electric wires are cased to the coal and cemented, like the air line. The air and one of the electric bore-holes are sunk close to the substation, as shown on page 239. The second hole for wires is some distance away, as it is considered safer and more convenient to handle the main power cable on the surface.

At the Rural Valley station a bore-hole 300 feet deep has also been sunk close to the rib, reaching some distance below the seam. This well supplies cooling water for the compressors, by means of an air lift, to the tank shown in the view of this station on page 239

The main water supply is from a creek near by, but the well is used during the summer, when the water in the creek is low.

ADVANTAGES GAINED.

The installation of this central plant enabled the company to discard 10,000 feet of eight-inch pipe line, together with many hundreds feet of smaller pipe, which are being lifted from time to time, as conditions permit. The advantages of this plan of installation are easily seen. The high voltage permits but small losses in transmission; the generation of power so close to the machines minimizes the loss of efficiency; and the mobility of the entire plant prevents waste of capital and labor in extending the development of the property.

ATTENDANTS.

While this plant is more than double the capacity of the former ones, only 13 men per 24 hours are required for the care of the main power-house and substations. Twenty-four men per 24 hours

were needed to look after the two original plants. At present the day force is as follows: Boiler-room, two men; engine-room, one man; one general utility man at the power plant, and one laborer at each substation, whose only duty is to see that everything goes on properly, the machinery being automatic and operating continuously. At night the general utility man is not on duty.

It is expected that before the field is entirely worked out, six to seven of these substations will be in use.

The officers of the Cowanshannock Coal and Coke Co. are: Mr. Adrian Iselin, President, New York City; Mr. Lucius W. Robinson, Punxsutawney, Pa., Vice-President and General Manager; Mr. James Craig, Yatesboro, Pa., Superintendent; Mr. Alexander Pride, Assistant Superintendent; and Mr. Chas. M. Means, Punxsutawney, Electrical Engineer. Mr. Robinson is also President of the Jefferson and Clearfield Coal and Iron Co., and President and General Manager of the Rochester and Pittsburg Coal and Iron Co., and Mr. Means is Electrical Engineer for these two companies as well.

The work of planning and installing the new power system devolved upon Messrs. Robinson, Means, and Craig, who deserve much credit for the responsibility assumed in evolving and carrying through such a radical plan to successful completion.

The writer is indebted to Messrs. Craig and Means for the information used in this article. The photographs reproduced were taken in August of this year, especially for this purpose.

Rural Valley substation; bare-holes for air, electricity, and water at the right.

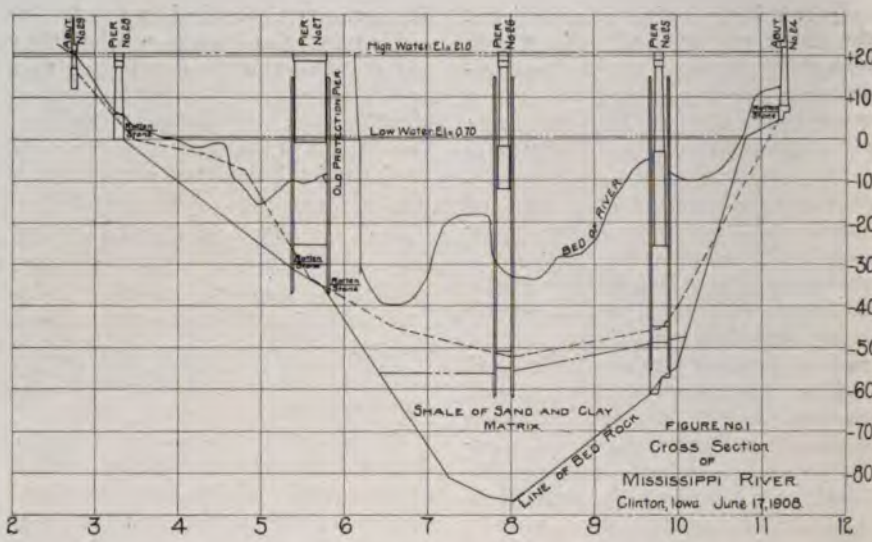


FIGURE No. 1
Cross Section of Mississippi River
Clinton, Iowa June 17, 1908.

TESTING FOR BRIDGE FOUNDATIONS.

*By F. H. Bainbridge,

RESIDENT ENGINEER CHICAGO & NORTHWESTERN RAILWAY CO.

This article is confined to bridge foundations, although much of what follows is also applicable to foundations for buildings and hydraulic structures and preliminary examination for tunnel construction.

GENERAL CONSIDERATIONS.

Two methods of testing only are effective, an open pit or well for shallow foundations and the core drill for deep foundations. Sounding with gas-pipe or rods in shallow foundations and the common well-drill in deep foundations are not satisfactory. Figure 1 shows two cross-sections of a stream at the same point, the dotted line being the line of supposed ledge-rock as determined by a well-drill operating a chopping bit; and the full line, the correct location of the ledge-rock, determined with a Sullivan "HN" Diamond Core Drill.

In general, two sets of borings should be made for an important bridge crossing; the first set, a number of borings on the center line of the proposed location, to determine whether the site is a favorable one, and, if favorable, to determine by approximate estimate the most economical location of the piers and the length of the spans. In a general way it may be assumed that the economical relation is reached when the cost of the substructure equals the cost of the superstructure; but inasmuch as the cost of the superstructure can be determined with considerable accuracy, while the cost of the substructure is involved in great uncertainty, the length of the spans selected should exceed that of the apparent economical relation. The length of spans chosen may also be influenced by other than economical considerations, such as government requirements, or the liability of ice to gorge against the bridge.

*Clinton, Iowa.

Having made a tentative location of the piers, borings should be made at each pier, and in the case of pneumatic or open dredged caisson foundations, one boring should be put down at each of the four corners of the caisson.

The preliminary borings may often be dispensed with when there are well records on both sides of the river in the vicinity. These well records can almost always be found in the various State Geological Reports, which can be had at any public library in the state. In case of the borings at Pierre, South Dakota, to be described later, the well records were so good that borings to determine the length of the spans were not necessary.

In cases where pile foundations are feasible and the river bottom is firm enough to lay concrete on, no borings are necessary, the required length of piling being best determined by driving experimental piles; but where the river bottom is soft, as it is in most streams with a sluggish or reversing current, borings should be made, the softer material being taken out dry with a saw-tooth bit. This is feasible in the hardest clay or the softer shales and gives a perfect knowledge of the material encountered. Cakes dry come are taken when feasible, a hard clay in every way suitable for a foundation may be overlooked and provision made for carrying the foundation further down than necessary.

VALUE OF BORINGS.

In pneumatic work an accurate set of borings with a core drill is of incalculable value. These advantages are:—

1st. The final location of the caisson can be accurately determined and cut stone and timber ordered without any waste or delay waiting for material for which no provision had been made.

2nd. The contractor in bidding on the work knows exactly what material is to be encountered, and will make a lower bid when there is no uncertainty. The difference in cost between handling in a caisson, material which can be taken out through the blow-pipe, and material which must be locked out in buckets is very great.

3rd. The piers can be located in the most economical position. Often a change of a few feet in locating a pier may make a difference in cost of tens of thousands of dollars.

4th. Much can be learned as to the character of the foundation that cannot be learned from the interior of the caisson. In limestone formations subterranean caverns are common, and in both lime and sandstone formations overhanging subterranean cliffs are found. The existence of these can be determined with the drill, but cannot be learned from the interior of the caisson.

INTERPRETING THE BORINGS.

Nearly the whole North American Continent north of the Ohio River and east of the Missouri River has at various periods been covered with glacial drift; in fact, the Ohio and Missouri Rivers were formed by glacial action. Below the recent alluvial deposits in a river-bed in this district will be found glacial deposits of sand, gravel, clay, till or boulders, sometimes all together in a heterogeneous mass. The extreme determined movement of the greatest glacial sheet was 1,300 miles. Boulders of granite from Canada and Minnesota were carried as far as Kansas and Missouri. One of the boulders in the river-bed is therefore liable to be mistaken for ledge-rock. Usually the character of the ledge-rock can be learned from state surveys and samples secured from the outcrops,

Testing Missouri River bed for bridge foundations at Pierre, S. D., on the Chicago and Northwestern Ry.

which are located in these surveys. When a core is obtained which can be identified as the same as ledge-rock it may or may not be the actual ledge. If the core is granite or some older formation than the ledge-rock it is certain that a boulder has been reached. More recent rocks sometimes exist as pockets in earlier formations, so that a mere difference in the character of the rock from the bed-rock is not conclusive evidence that bed-rock has not been reached. When such a condition is liable to be found in any locality it will usually be mentioned in the State Geological Surveys. Boulders of granite and other hard rocks must be removed by placing sticks of dynamite at the bottom of the stand-pipe, withdrawing the pipe, and exploding with an electric battery. Boulders of softer rock can be cut up with the chopping bits and the casing driven through them. As boulders are usually separated by a matrix of sand or clay, the drop of the rods and the wash will show them as boulders and not bed-rock in most cases, though this is not always conclusive, as pockets sometimes filled with sand are common in limestone ledges.

No definite rules can be given to cover all cases, and it is best, especially where there is any uncertainty, to put down a hole at each of the four corners of a pier. Where the drill strikes first rotten or sap rock, gradually increasing in hardness until known ledge-rock is reached, this is conclusive evidence of bed-rock. It is best to take out very soft rotten rock with a saw-tooth bit working dry.

PIERRE, SOUTH DAKOTA, WORK.

Drill tests for the foundations of the Chicago and Northwestern Railway Bridge across the Missouri River at Pierre, South Dakota, were begun in December, 1905. The drill used was a Sullivan Machinery Company's "HN" Diamond Drill, operating two-inch core bits; 4½-inch stand-pipe and three-inch casing, both with flush joints, were used. Borings at the sites of the river piers were made from the ice. In general four holes were put down at the site of each pier. On diagonally opposite corners holes were put down to about 90 feet below low water, and on the other two corners to 60 feet below low water. Thirty-three holes in all were put down, aggregating a length below the river-bed or ground level of 2,379 feet, of which 1,456 feet was in sand, gravel, and boulders and 923 feet in shale, with occasional small lenticular pieces of limestone. On the east or left bank heavy beds of glacial drifts were encountered and there was some difficulty in putting down stand-pipe and casing. The boulders were broken up with dynamite. In shale, saw-tooth bits were used entirely, the bortz bit being used only in the limestone pockets.

The work of setting up the drill was started December 5, 1905, and the first boring started December 8, 1905, with one shift working 10 hours. On January 17, 1906, a second shift working 10 hours was put on.

Shale was found practically level over the entire cross-section at 42 feet below water. There was apprehension upon encountering an underground flo

Sullivan "308" Diamond Drill testing the bed of the Mississippi at Clinton, Iowa.

of water in the upper strata of the shale, but in no case was this more than a few feet below the top of the shale.

Cadmia for the permanent piers penetrated the shale from four to six feet and the material encountered was accurately described in the record of the borings. The cost of the drilling, including 10 per cent. for depreciation of plant and tools, was about $2,400, or about one dollar per foot. The photograph on page 242 shows the drill shanty on the ice of the river.

DRILLING AT CLINTON, IOWA.

In 1908 the Northwestern Railway began tests to locate suitable foundations for a new bridge over the Mississippi River at Clinton, Iowa. The same apparatus, tools, piping, etc., were used as at Fierre, but the manner of working and the materials encountered were essentially different. These borings were started in April, and it became necessary to mount the drill on a scow. The photograph on this page shows the drill mounted ready for work. The scow was 15 feet wide, 32 feet long on the bottom and 37 feet long on top, with a draft of 18 inches when loaded. Experience in rough water showed that a scow 10 feet longer on top with somewhat more rake to the ends would have been more serviceable. The tripod consisted of three pieces of Douglas fir, 3 by 8 inches and 32 feet long. An eight-inch wrought-iron pipe near the center of the scow, bolted with a pipe flange to the bottom of the scow, made a well for passing the stand-pipe, 4½ inches in diameter, and the casing, three inches in diameter.

The materials encountered were in order as follows: Recent alluvial sands, glacial drift of gravel, sand and boulders,

a shale consisting of sand with a clay matrix, and finally limestone bed-rock. The upper strata of bed-rock was identified by fossils and general appearance as belonging to the Gower stage of the Niagara Series of Silurian Rocks. This overlaid conformably rock of the Delaware stage of the same series. In the middle of the river the Gower rock and nearly 50 feet of the Delaware rock had been entirely eroded. Great care was taken to ascertain the possible existence of subterranean pockets or overhanging cliffs in the rock. Only two of these pockets were found, however, both in the same boring, and these were only one and six inches in depth. Both were filled with sand, consisting of about equal parts of quartz and dolomite sand. Some of the borings were carried down 30 to 40 feet into the bed-rock to determine the possible existence of these subterranean pockets.

All the boulders encountered were such as could easily be broken with the chopping bit and no dynamite was found necessary. To determine the consistency of the shale, cores were taken out with saw-tooth bits working dry, showing perfectly the consistency of the material. The saw-tooth bit or the chopping bit working with the pump gave no idea of what this material was, and without the expediency of the dry core an excellent foundation would have been overlooked, and a foundation sought 30 feet lower. It is intended to use pneumatic caissons in all the piers except the shore piers.

Borings in the limestone were made with a bortz bit when the water was still, and with the chopping bit, taking occasional cores with the saw-tooth bits. Fully 95 per cent. of the boring in the limestone was made with the bortz bit. The work of mounting the drill was started April 2nd, and the first hole begun April 7th. The work was finished June 6th, working one shift of 10 hours per day.

The aggregate length of casing put down was 692 feet. The aggregate length of casing driven through hard material was 406.5 feet. The aggregate length of borings in shale was 86 feet, and in limestone, 226 feet. The cost was as follows:—

Labor	$456.16
Coal	124.41
Depreciation of bortz, estimated	200.00
Scow	287.24
Depreciation on tools, pipe, etc.	200.00
	$1,267.81

The scow still has a value which is somewhat uncertain. Omitting this credit, the cost of the work amounted to $1.83 per foot.

The Board of Water Supply of New York City is preparing to drive a tunnel under the Hudson River at Cornwall, N. Y., for its new aqueduct. Four 3,000-foot Sullivan drills are to be used for testing the rock below the river-bed by means of horizontal holes bored from shafts on each bank.

Sullivan "B" Drill, capacity 3,000 feet.

MACHINE COAL-MINING IN ILLINOIS.

The Illinois Coal Report for 1907 has just been issued by the Bureau of Labor Statistics—Mr. David Ross, Secretary. It shows a total tonnage for the year, of 47,798,827, as against 38,317,581 for 1906, an increase of 9,481,040 tons, or 22.1 per cent. Of the total amount, 14,690,454 tons were cut by machines, or 30.5 per cent. of the total. In 1906 only 25.0 per cent. of the total product was machine mined, showing a gain of 22.7 per cent. in the use of machines.

"The mines reporting the exclusive use of machines increased only five per cent. over last year, and the number of machines used only nine per cent., while the tons mined increased 26.6 per cent. The total number of mines using machines increased 18.8 per cent. over last year; the number of machines 14.9 per cent., and the number of tons cut 51.5 per cent., showing certainly a remarkable increase in the effectiveness of machine mining.

"Table 38 presents the record of mining machines in use in the coal-mines of the state for a series of eight years. The number of machines in use this year was 1,101. This is 143 more machines than reported for last year. Several of the different kinds of machines have largely increased in the number in use during the past few years."

Table 38.—*Name and Number of Mining Machines in Use for Eight Years.*

Year	Undercutters	Shortwall Machines	Longwall Machines	Combination Machines	Total Machines	Mines Reporting Machines	Machines per Machine Mine	Tons Mined by Machines	Per Cent. of Total Product	Total Mines	Total Product
1900	40	134	107								
1901	46	157	114								
1902	41	161	116								
1903	43	178	126								
1904	43	187	136								
1905	43	195	140								
1906	43	240	144								
1907	50	246	144								

An interesting fact in connection with machine mining in this state is that the opposition to the use of machines on the part of labor is such that machines in mines where hand labor also is employed cut less coal than mines using machines altogether. Thus, in the sixth district, two exclusively machine mines working 18 machines produced 329,012 tons, while in two mines where hand miners were also employed 12 machines got out only 281,242 or 29,369 tons per machine in the first instance, against 23,437 in the second. In the eighth district, 235 machines cut 13,715 tons each in exclusively machine mines, while 126 machines in mines where hand labor was used jointly cut but 11,000 tons each. The total for the state shows that 749 machines are used in 60 mines where no hand mining is done, and that 357 machines mine a part only of the product of 41 other mines. The first machines average 13,930 tons. The second, 11,361 tons, or 18.5 per cent. less.

Another source of economy traceable to the use of machines for undercutting the coal is the saving in powder. In 280 mines where hand labor—*i. e.*, shooting from the solid, without undercutting—is customary, 1,003,321 kegs of powder were required to shoot 23,863,267 tons, or 23.78 tons per keg. On the other hand, in 57 mines in which the coal was all undercut by machines 10,426,860 tons were broken down by 108,591 kegs of powder, giving an average of 96.02 tons per keg used. At $1.75 per keg, this shows a powder charge of 6.8 cents per ton on hand-mined coal, and of 1.8 cents per ton on machine-mined coal.

Sullivan Diamond Drills were recently employed by the Water Power Commission of Austin, Texas, and by the United Missouri River Power Company of Helena, Montana, in locating suitable foundations for dams. The drills were mounted on scows.

Gantt's Quarry, Alabama

ALABAMA MARBLE: HISTORY, PRODUCTION, AND USE.

Gantt's Quarry, three miles from Sylacauga, in Talladega County, and 50 miles from Birmingham, is the site of quarries which give Alabama high rank as a marble-producing state.

These deposits were discovered in 1836 by a Scotchman named Herd; in 1845 Dr. Edward Gantt began work in a small way, with primitive methods. Slave labor was employed, and the blocks were lifted with wooden wedges. These blocks were used principally for headstones and slabs, which may still be seen in many of the cemeteries all over the state.

The war halted these operations, and as Dr. Gantt died in 1867, the quarries lay idle for nearly 40 years, until northern capital was interested and the property bought at a court sale in 1898. The Alabama White Marble Company was formed and work begun on a small scale, but it was not until 1902 that public attention was drawn to the superior qualities of this marble, by a block exhibited at the Alabama State Fair at Birmingham. It is interesting to note that the Vermont Marble Co., the largest producer in America, examined the property in 1878. The late Senator Proctor reported the marble as undesirable and the physical conditions adverse to successful operation.

These deposits include both blue and white stone, but at present the white only is developed. Some of the layers are of a rich creamy tint, and some have

the bluish white tinge of Italian marble.

There are also layers which yield veined or clouded slabs, presenting a variety of effects for decorative purposes. The cream white, however, is the chief product of the quarries. These marbles are declared to be the equal of Greek and Italian marbles in their life, warmth, and permanence of color; and superior even to these in their adaptability for carving, molding, and other monumental and structural purposes.

SIZE OF SLABS.

A distinguishing characteristic of Alabama marble is the large size of slabs that can be secured from it. With sufficient saving to allow for quarrying, slabs can be obtained of any size, limited only by the capacity of the saws available. This will enable architects to adopt designs for panels with dies larger than any hitherto obtainable. The resulting possibilities, where a noble and dignified interior marble treatment is desirable, will be readily appreciated.

DURABILITY AND STRENGTH.

Alabama marble is an exceedingly pure calcium carbonate, the proportion being about 98.4 per cent. Of iron there is barely a trace, and of iron pyrites there is none. It contains nothing that would promote either staining or chemical disintegration. Its durability is amply attested by old tombstones, over fifty years old, on which the carving and tool marks are as fresh and perfect today as when the work was done. The weathered surfaces on the old outcrops, as they are uncovered at the quarry, show a thin skin, not more than one thirty-second of an inch thick, of material that is slightly softened; below the skin the marble is as sound and hard and pure as it is a hundred feet down in the deposit.

The crushing strength of this stone, in three-inch cubes, is from 13,000 to 17,000 pounds per square inch. Its strength is more than ample for all purposes. When cut with the beds, it is also possessed of very great transverse strength. This has never been tested accurately, but at the company's mill its employes carry thin slabs by the edges, in a horizontal position, with perfect safety, which, in any other marble, would inevitably break under their own weight.

PRESENT OPERATIONS.

The Alabama White Marble Co. was succeeded in 1906 by the Alabama Cream White Marble Co., with a capital stock of $1,000,000. The company name has recently been altered to The Alabama Marble Co.

The photographs on pages 246 and 248 show the character of the development. Since the picture on page 246 was taken, the quarry has been extended behind the derrick in the center, and is now 85 x 250 feet in area. The company's property covers 680 acres, which includes a vein of white marble a mile long and 500 to 600 feet thick. The deposit, as shown by the photographs, dips at an angle of about 35 degrees, and the layers are from two to five feet in thickness. Thorough prospecting with a core drill shows that the marble persists to a depth of 320 feet under the present quarry. Twelve bore holes, drilled in various parts of the vein, have failed to find bottom. The overburden consists

Quarry blocks of Alabama marble.

Quarry of Alabama White Marble Co., Gantt's Quarry, Alabama, showing Single- and Double-Head Sullivan "Z" Channelers.

of light soil, about 15 feet in depth, which renders stripping comparatively easy.

CHANNELING.

The photographs show clearly the methods used in quarrying this deposit. The steep pitch of the beds presents some difficulties not encountered in other fields. Sullivan Class "Z" Swivel-Head Channelers are employed for ordinary work, using regular five-piece gang marble bits. It is necessary to prop up the track for these machines with short posts, as shown in the pictures, to give the channelers a level plane on which to operate. The cuts across the pitch, lengthwise of the quarry, are put in at right angles to the layers, which makes it necessary to swing the cutting engines of the channelers at an angle of about 35 degrees from the vertical.

These channelers are designed especially for heavy work and rapid cutting under conditions of this nature.

In cutting up to the end walls, the cutting heads may be swiveled on a steel plate, to put in transverse cuts in the same plane as the floor channel, up to 30 degrees, if necessary.

When cutting up and down the pitch, across the quarry, three methods are used: drilling and broaching with rock drills on quarry bars, as shown in the photograph on the front cover; "Z" channelers, on track made level by props or cribbing (see above cut); or third, and usually, when long runs are possible, by

Sullivan Side-Hill Channeler, "Class 64," in West Rutland quarry of Vermont Marble Co. Instead of winding the cable on a drum on the axle, as described in this article, the cable here passes over a sheave and is stippled to a counterbalance car running on rails parallel to the machine track.

mount of a Sullivan Class "64" *S*-de-Hill Channeler. This machine is lighter than the Class "E," and the axles of the trucks are provided with drums, to which a wire rope is attached. This rope passes around a sheave wheel at the upper end of the track, and is wound up or paid out by the feed engine on the channeler. This machine cuts at an even rate of speed up or down the incline of about 35 degrees. The tracks are gibbed to the rails to prevent overturning. As all cuts are made to the bed planes, very little drilling is required to raise the blocks, but, instead, wedges are driven into the split. The company employs seven Sullivan Channelers, three Class "Z," one "double-head" "Z" machine with two cutting engines mounted on the same frame, the "64" side-hill channeler referred to, and two Class "VX" side-hill machines, which are also used somewhat for the hill-climbing work and for other lighter channeling, for which they are well adapted. These machines run on a track with a rack-rail, which is engaged by machine-cut teeth on the wheels.

The drilling is done with Sullivan 2½-inch Block Drills, mounted on four Sullivan quarry bars, and with 3½-inch Sullivan tripod drills.

FINISHING PLANT.

When cut into blocks of the desired size, the stone is hoisted from the quarry by two wooden 20-ton derricks, one at each end, and by one new 35-ton steel derrick in the center of the quarry, with a 100-foot mast and 95-foot boom. The photograph on page 247 shows the appearance of the blocks as they come from

Part of the mill and shipping yard, Alabama Marble Co.

the quarry. The equipment for handling the stone between the quarry and the mill, and from the latter to the railroad cars, includes a 75-horsepower hoisting engine, a 20-ton locomotive crane, and a 35-ton dinkey locomotive. A 15-ton traveling crane is about to be installed between the mill and the finishing plant; it will be 70 feet long, with a 26-foot lift.

The photograph on this page shows a portion of the mill, which is now being enlarged. The new plant will be 51 x 300 feet, and will contain 20 gang saws, five rubbing beds, two fitted with tile machinery, six polishers, a combined circular and straight-line planer, a diamond saw and carborundum machine, and a lathe 16 feet long with four-foot swing.

POWER PLANT.

A new 500-horsepower simple Corliss engine will drive the saws direct, and will furnish power to a 200-KW generator for operating the other finishing machinery electrically. Air hand tools for carving and finishing are supplied with power from an 1,800-foot cross compound, two-stage compressor, recently installed.

Steam is provided at 160-pounds gauge pressure, with 125 degrees of superheat, from two 300-horsepower vertical water-tube boilers. The concrete foundations for two more 300-horsepower units are already set. The steam pressure in the mains which supply the channelers and drills is reduced to 120 pounds.

The plant now employs about 175 men, and more will be added when the new finishing plant is completed. Railroad facilities are provided by a spur track, connecting with the Louisville & Nashville Railroad.

EXAMPLES OF USE.

For interior finish, Alabama marble from the quarry of this company has been used in New York City, in the rotunda and other parts of the main story of the new Customhouse, in the Night and Day Bank, and in the banking-room of the new building of the Trust Company of America, No. 37 Wall Street. It has also been used in the National Metropolitan Bank, opposite the Treasury Department, in Washington, D. C.; in the Brown-Marx building and the Florence Hotel in Birmingham, Ala.; and in numerous other buildings.

For exterior work, Alabama marble from Gantt's Quarry has been used in the Maryland Institute, in Baltimore, Md.; in the Connecticut Savings Bank, in New Haven, Conn.; in the new Court-House at Somerville, N. J.; and in other buildings.

The officers of the company are Henry Evans, President, New York; Major John Stephen Sewell, Vice-President and General-Manager, Gantt's Quarry, Alabama; G. T. Hollister, Vice-President, New York; E. E. Bigney, Secretary and Treasurer, New York. A sales office is maintained at 156 Fifth Avenue, New York City, and an office and ware-rooms at Avenue E and 21st Street, Birmingham, Ala. The company has a large number of orders for all classes of work now on hand, and looks forward to a rapid increase in the popularity of Alabama marble.

MINE AND QUARRY is indebted to Major Sewell and also to the *Manufacturers' Record* for the information contained in this article.

PROGRESS ON THE ASHOKAN DAM.

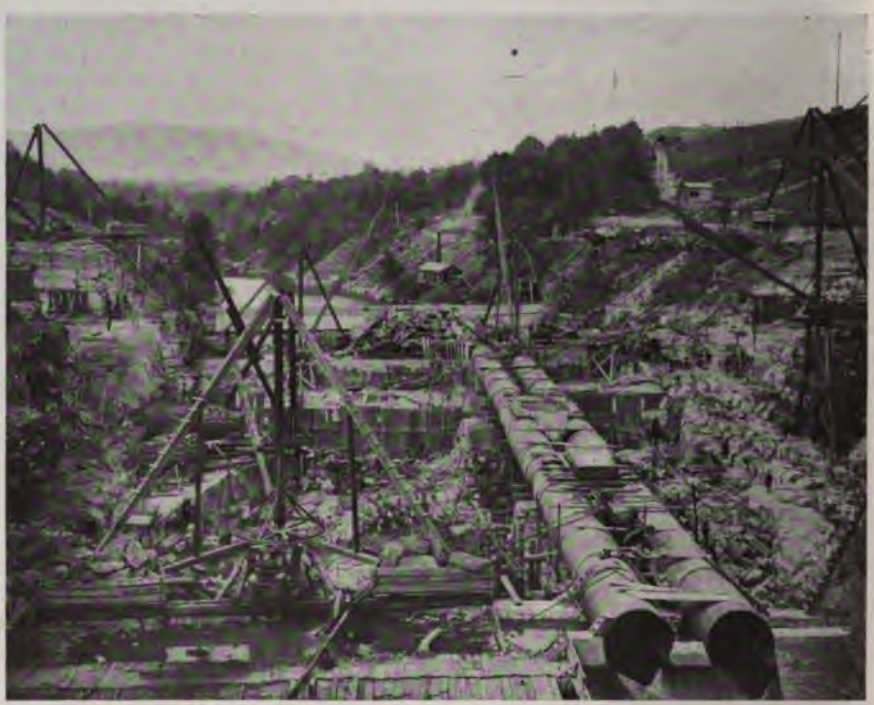
By JAMES H. RIDER, JR.*

The Ashokan Dam, now under construction near Brown's Station, Ulster County, New York, forms a part of the new water system which the Board of Water Supply is establishing for the City of New York. The contractors for the work are MacArthur Bros. Co. and Winston & Co., builders of the Wachusett Dam, in Massachusetts, and the Cross River Dam at Katonah, New York.

Masonry and earth dams across the Esopus and Beaver Kill Creeks and across low portions of the valley will form a storage basin about 12 miles long and one mile wide, with a capacity of

*31 Broadway, New York.

Bullivan Diamond Drill testing the bed of Esopus Creek, Brown's Station, N. Y. on the site of the Olive Bridge Dam



General view of Ashokan Dam construction in September, 1908, looking up-stream.

120 billion gallons, the largest reservoir in the world for high pressure water supply. The total length of these dams and dykes is nearly four miles. The water collected will cover the ground now occupied by 11 villages, to an average depth of 18 feet, forming an area of 8,000 acres, with a shore line of 50 miles. It is the intention of this article to deal merely with the main dam—known as the Olive Bridge Dam—across the Esopus Creek.

At the site of the dam, the Esopus Creek originally ran through a rock gorge about 200 feet wide and 40 feet deep. The rock is a hard, blue sandstone, very gritty, occurring in nearly horizontal layers from three to four feet thick, and occasionally interspersed with slate and shale.

Across the channel, above and below the dam, cofferdams were built by the Board of Water Supply prior to the letting of the contract, and two riveted steel pipes, eight feet in diameter, now carry the flow of the creek.

The dam is to consist of a concrete masonry portion 190 feet wide at the base, about 1,000 feet long, and 250 feet from the bottom of the cut-off to the crest. On each end of the masonry section there will be wing dams of earth with concrete core walls, making the total length of the dam 4,800 feet. The cross section is similar to that of the Wachusett Dam.

In order that all water-bearing seams under the dam may be sealed, a cut-off 25 feet wide has been excavated across the creek, going down 40 feet below the level of the foundation of the dam. To avoid disturbance of the existing rock

Cut-off at Ashokan Dam; Sullivan Channelers in rear. The material between the walls is removed by drilling and blasting.

by blasting, channeling was resorted to, and four Sullivan Class "Y-8" Channelers with air reheaters were installed. Both sides of the cut-off were channeled in life averaging six to eight feet. The bit used is the three-piece gang, made up of three pieces of 2½ x 1¼ inch steel, which was found to be the most satisfactory for this work. The cut-off is completed in the bed of the creek and is now being extended into the sides of the gorge to a line about 100 feet above the foundation level, where the rock ends. This part of the work will look roughly like a flight of steps in section. At the time of writing it is estimated that there is still about 100,000 square feet of rock to be channeled.

Above the cut-off the rock bottom has been prepared for the placing of Cyclopean masonry, which has already begun. Solid masonry piers are under construction to support the pair of pipes, to guard against danger from the overflow of ice in the coming spring. As soon as the masonry of the dam reaches the level of the pipes, a conduit will be built through the dam into which the stream will be diverted. The pipes will then be removed, the piers under them forming an integral part of the dam.

All machinery except steam shovels, locomotives, and the crushing and mixing plant is operated by compressed air. Power is at present furnished by two cross-compound condensing, two-stage

Sullivan "Y-8" Channeler run by air, on the second "lift."

air compressors with a combined capacity of 7,000 cubic feet of free air per minute. A third unit is practically installed and the foundations for a fourth are in place.

When all the compressors are in operation, a uniform pressure of 100 pounds per square inch will be maintained.

Four 15-ton cable-ways are in operation. The towers have a movement of 700 feet at right angles to the axis of the dam, giving perfect control over the work.

Adjacent to the head towers of the cable-ways is the big crushing and mixing plant. Stone will be brought from the quarry, about two miles distant, over a railroad built by the contractors, which involves the construction of a bridge about 1,200 feet long over Esopus Creek.

At present there are about 2,000 men employed on the entire work. This number will probably be doubled before the reservoir is completed. A camp has been built to accommodate the workmen, with well-laid-out streets and a complete sewerage system. It is estimated that this small city will eventually have a population of between five and six thousand.

Sullivan Low-Vein Room-and-Pillar Coal-Mining Machine, Class "CE-6," with frame removed.—Rear view, showing handling gear.

A NEW COAL-MINING MACHINE FOR LOW VEINS.

For several years the use of the Sullivan Continuous-Cutting Electric-Chain Coal-Mining Machine has steadily increased, as operators in various fields of this country have learned to appreciate its advantages. The success of this type has been such as to warrant the development of a similar machine for mining coal, both in rooms and on long-wall faces, in thin seams.

The Sullivan Low-Vein Room-and-Pillar Mining Machine, designated as "Class CE-6," is mounted upon a steel shoe or frame for convenience in transportation and for making its first cut. In making the first or rib cut, the machine moves forward out of this frame, which is cut away at the left-hand side. The rear or anchor jack is then set in the right-hand corner of the room, and the front jack at the other extremity of the working face. The machine propels itself across the face on a feed chain stretched between these two jacks, cutting the entire room at a single operation. The accompanying illustration shows the machine in the above position, with the two jacks.

It will be noted that the machine travels on a sheet-steel plate, occupying the least possible space. No rollers or rails are required on which to run the machine while making this cut. It will also be noted that this is virtually an adaptation of the long-wall principle to room work. The machine is not withdrawn from the coal after making the first or sumping cut until the left rib is reached.

This method accomplishes notable economies in mining and in handling the coal. Not only is much time and labor saved that is ordinarily employed in backing the ordinary type or breast machine out from the coal and moving it over by hand for the next cut, but as there is no frame or pan behind the machine, as in the case of the breast type, it occupies but one-half as much space as the latter in front of the coal, thus allowing props to be permanently set within six feet of the face, and reducing the distance which the coal and debris must be moved by the loaders. As the Sullivan machine cuts on the bottom, at all times closely following the contour of the

Crossing the face in a single operation, without withdrawing the machine from the coal or moving jacks.

floor, no coal is left after it, to be raised by hand, nor are sprags or ribs left at the rear of the cut to interfere with blasting to the best advantage.

The machine has been carefully designed to secure strength, durability, and at the same time low height and compactness of the working parts. The motor is placed horizontally instead of vertically, as is usual in the ordinary machines of this type, and is wound for 210, 250, and 500 volts direct current, as required by mine conditions. When cutting, the machine stands 21 inches high and occupies a space of five feet three inches between the coal and props. The kerf or height of mining is four and one-half inches, and the depth of cut ranges from 63 to 75 inches. The machine is moved from place to place in the mine on a special self-propelling electric truck. When on this truck the machine stands 30 inches above the rails, although, if desired, a truck is furnished with drop axles, reducing the total height to 27 inches. The machine performs all operations under its own power, includ loading and unloading from the truck that hand labor is reduced to the m imum. The machine weighs 3,100 pou and the power truck 900 pounds. motor develops 30 horsepower at 1, R. P. M.

This coal cutter has proven very sa factory to operators on account of high cutting speed, from 16 to 39 inc per minute, small bulk and ease of ma ulation and carriage. It is capable operating on pitches of 30 degrees wh rooms are driven across the pitch, of 12 degrees when rooms are dri straight up the pitch. As indicat the capacity of this type, it may mentioned that at the mines of the Coal & Coke Co., Logan County, W Virginia, a Sullivan Class "CE" mach has undercut, on a long-wall face, feet to a depth of six feet one inch eight and one-half hours, thus produc over 500 tons of coal. While these chines naturally make a better show in wide rooms, experience has sh

that they are also much more economical than the breast cutter in narrow rooms and even in entries.

In a mine at Murphysboro, Ill., a green runner has cut seven eight-foot entries in less than five hours, and later on cut eleven nine-foot places in 7½ hours, including two moves of over 300 feet each.

The following extract from the Brisbane, Queensland, *Daily Telegraph* for May 13, 1908, describing a visit to the largest colliery in Queensland, known as the Blackheath Mines, shows the impression made by machinery of this class upon a "layman." —

"At one place a most interesting exhibition of the wonderful, almost human, operations of a Sullivan coal-cutting machine was witnessed. This marvelous contrivance, which weighs about two tons, and which is operated by a 30-horsepower motor, capable of developing up to 50 horsepower, if need for so much power arises, was seen cutting at an astonishing rate of speed 6 feet 6 inches into the 12-foot wall, right across its 25-foot face, without a break. In performing this herculean task, the machine gradually hauled itself along the face, while its two attendants, together with the visitors, calmly watched its progress. Directed by the men, the machine afterwards pulled itself back to its track, and, carrying with it all its necessary gear, eventually propelled itself away to another working until the 60 tons, which was awaiting the shock of the explosive, had been taken from the face first operated upon."

Sullivan Coal Cutters of this type have been in use for the past three or four years in Australian mines, with very successful results. In New South Wales, the principal coal mining field in Australia, there are 16 collieries employing mining machines. Sullivan machines are used in 12 of these mines. In the 16 machine mines there are 62 coal cutters of the chain type in use, of which 41 are of the Sullivan Class "CE" room-and-pillar type. There are also four class "CH" long-wall machines.

Electric Low-Vein Long-Wall Machine in position to cut from left to right. Height, 31 inches.

Sullivan Rock Drills

Sullivan Drills do more work and cost less for repairs than any other similar machines, because of the excellence and fitness of the materials used in their construction, the precision and care with which the parts are made and assembled, and the forty years' experience of this company in designing, building, and using rock-cutting tools.

CATALOGUE 160

Sullivan Machinery Co.

BIRMINGHAM, ALA.
BUTTE
CLAREMONT, N. H.
COBALT, ONT.
DENVER
EL PASO
JOPLIN, MO.

RAILWAY EXCHANGE

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MINE AND QUARRY

SINKING AN ANGLE HOLE WITH A SCAMPER DRILL

AUTOMATIC STOPPAGE OF HOISTS

VERMONT MARBLE

DRIVING A SEWER WITH HAMMER DRILLS

SULLIVAN MACHINERY CO.

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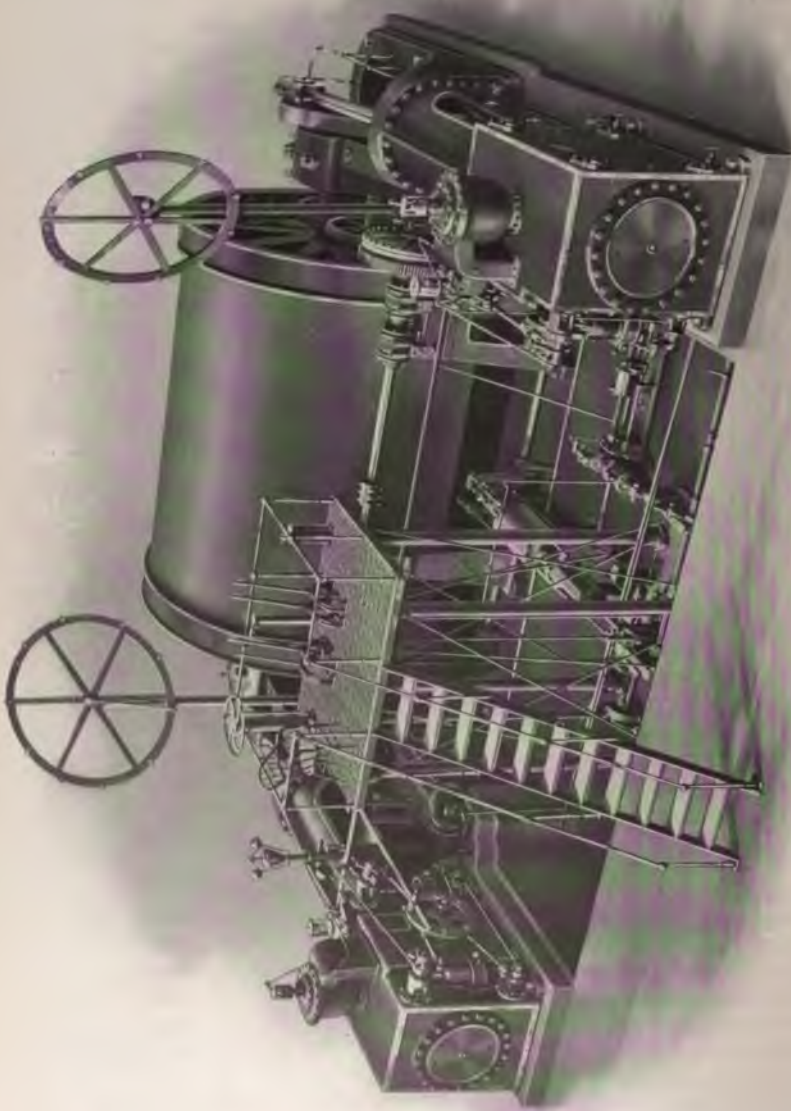
CHICAGO

MINE AND QUARRY

VOL. III. MARCH 1



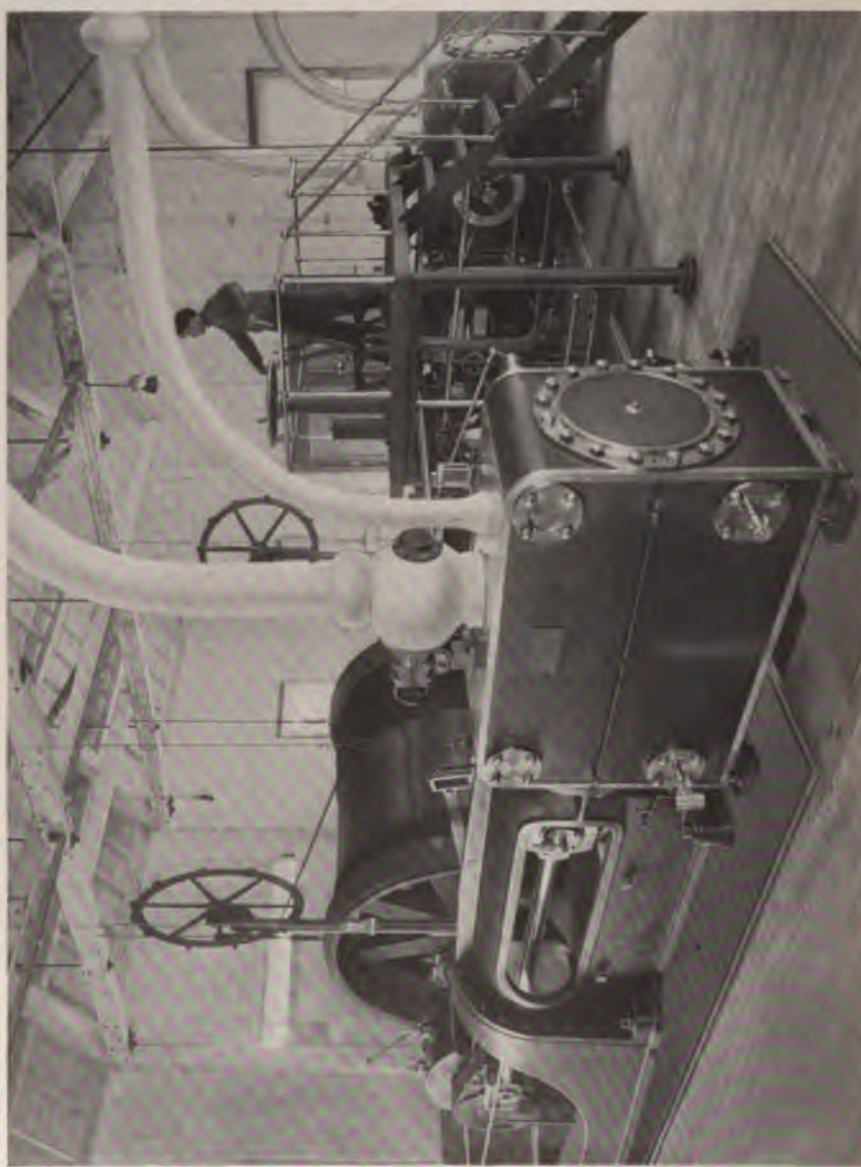
Sullivan First-Motion Hoist of Centennial Copper Co., at Calumet, Mich. Dimensions: Engines, 36 x 60 inches; drum, 15 feet in diameter by 15 feet long, keyed to the shaft. This hoist has a capacity in depth of 5,000 feet and a hoisting speed of 3,500 feet per minute.

AUTOMATIC STOPPAGE OF HOISTING ENGINES

By A. T. Snow*

The Double Drum Sullivan Hoist of the Port Henry Iron Co., Port Henry, N. Y.
Drums 7 feet in diameter, Corliss Engines, 20 x 42 inches.

[illegible] antagonism to new mechanical [illegible] instead of attempting to make the most of them engineers frequently [illegible] take the finest piece [illegible] made the machine [illegible] and that there was [illegible] [illegible] hoisting engineer to take care [illegible] A great many engineers [illegible] [illegible] have made [illegible] [illegible] [illegible]



Sullivan Corliss Hoist at the Prince of Wales Mine, Ohio Iron Mining Co., Negaunee, Mich.

A Drum Shaft for a Large Hoist. (38 ft. 10 in. long.)

The by-pass throttle is also very convenient to use instead of the main throttles when hoisting officers and miners or examining the shaft. Due to the small size of the by-pass throttle and the small amount of steam admitted through it, a large hoisting engine can be much more conveniently controlled with it than with the large throttle.

The automatic throttle-closing device is not only a means of safety, but a means of economy as well. A great many hoisting engineers will not shut the throttle until late in the trip, at least part of the time. The hoist is then running at such a speed that the brake has to be applied to arrest the momentum long before the landing is reached, whereas had the throttles been closed several revolutions earlier that much steam would have been saved, instead of being wasted in the neutralization of its energy by the brakes.

Several instances are recorded in which the hoisting engineer has come up to a level, taken on a load, and, by mistake, reversed the engine and lowered the load, instead of hoisting it. The down-going skip pulled the engine backwards at full speed, with the steam admitted to the cylinders in the same direction, thus acting with gravity, instead of against it.

But even though the speed of the machine was controlled by the down-going weight and not by the steam, the automatic brake was applied, and with the exception of breaking a part of the overhead sheave, no damage was done. Had not the automatic brake gone into action the loaded down-going skip would have shot the empty up-coming skip through the top of the shaft house.

SUMMARY

All Sullivan hoisting engines are now furnished with these safety devices. To sum up, they consist, first of a throttle-closing device, which automatically closes the main throttles, at a predetermined point in the hoist on each and every trip. The engineer is *not allowed* to close the throttles; the device interlocks with the engine reverse, so that the engineer cannot reopen the main throttles until he has thrown his reverse lever. The use of the by-pass throttles has been explained above. Second, they have an automatic brake, which goes into action at a prede-

DIGGING A SEWER WITH HAMMER DRILLS

the trench averaging 3 feet in depth. In this section the pipe is laid in and covered with portland cement concrete (see page 268). A feature of difficulty on this section is presented by a number of small culverts, through which the sewer is laid, without disturbing the surface of the ground. One of these is 300 feet long and 4 feet high, and three others, 60 feet each in length, with a semicircular cross section 4 feet high at the center. The line of the sewer was against the abutment, as shown in the small sketch (page 267).

Bloomington is in the oölitic stone district of Indiana, and in practically the whole length of this sewer system, solid rock is ecountered below clay from two to four feet deep.

The rock encountered varies from soft oölitic limestone to a bastard stone so hard that it wears the drill bits rapidly. The irregularity of the formation presents other difficulties, since the solid stone is

Sullivan "D-15" Drills in the Trench.

[illegible] gravel and [illegible] ; [illegible] the surface [illegible] with three to [illegible] water. The depth of rock [illegible] averages from [illegible] feet per hour.

[illegible]

[illegible] the [illegible] [illegible] [illegible]

Laying Pipe in Concrete.

Drilling alongside the Bloomington Gas Works.

Sullivan Channelers Opposite the Court House.

The Creek or "Branch."

Air for the drills is supplied at 110 pounds gauge pressure from two single-stage compressor outfits, one driven by steam and one by belt, from traction engines. Each plant supplies air for six drills, and is moved to a new location when the drills reach a distance of 1,500 feet from the compressor. (See page 269.)

A small reheater, improvised from an oil stove, is provided at each hammer drill, and materially increases the efficiency of the plant.

The Purification Plant.

CHANNELERS

Page 268 shows two Sullivan track channelers, which were installed when the work began, to put down the heavy rock cuts in the center of the city. It was expected to find solid oolitic stone here, but instead the rock was very irregular and hard, interspersed with seal seams and boulders. The channelers were therefore replaced by hammer drills, which did the work satisfactorily.

The work described above is now more than half completed. The total cost of the work to the city will be $100,000, including the purification plant.

Acknowledgment is made to Mr. W. H. Harris, secretary and manager of the Independent Construction Co., for data and photographs. To Mr. Harris is due much credit for ingenuity in solving the problems encountered in this enterprise.

Preparing for a Blast.

The Air Compressor Outfit.

Valley Quarry of the Norcross-West Marble Co., Dorset Vt.

VERMONT STATE

A Sullivan "Class 6½" Channeler in the Dorset Quarries.

deposit of marble at the foot of Mt. Aeolus, covered over with from only 3 to 12 feet of dirt and gravel, the layers being nearly horizontal.

Forty test holes were put down over widely separated points of the area, to an average depth of 100 feet. Although cored directly across the grain, many of the cores obtained were over 20 feet long, showing a deposit of building marble of unusual extent and soundness.

While there is doubtless a great depth of marble on this property that has never been penetrated by a core drill, it is possible to determine approximately the amount of stone in the investigated area. Figuring on this basis alone, it reaches the enormous total of four billion cubic feet.

EQUIPMENT

The quarry is now equipped with a modern and complete plant, consisting in part of 19 Sullivan channelers, Class "6½," 6 Sullivan gadders, 7 derricks of from 20 to 50 tons capacity and boilers generating 400 horse power. A railroad six miles long was built to Manchester, Vt., to connect with the Rutland R. R. At this place a well-equipped mill of 16 gangs of saws was constructed with a 35-ton traveling crane, 550 feet long.

With this equipment the output from this deposit has run as high as 560,000 cubic feet in one year.

METHOD OF REMOVING BLOCKS.

The introduction of Sullivan quarry machinery her ehas so revolutionized quarrying, reduced the cost of production, and made possible structure heretofore unattainable, that it may be interesting to describe the methods used in laying out the work and in removing blocks from this deposit.

In an important building, plans are first drawn showing exactly the sort and sizes of stone required. Inasmuch as the economical quarry block is ordinarily much larger than the finished stone in any given structure, the quarry block is gotten out to make several of the smaller sizes. Having ascertained the size of the blocks desired, the channeling of the quarry floor is begun. In this deposit, as has already been stated, the layers of marble lie in a nearly horizontal position, making it comparatively easy to lay the track so that the machines will have a level plane on which to operate.

The accompanying photograph shows a Sullivan Channeler, Class "6½" in operation. The machine, driven by steam power, moves back and forth over the track at a rate of about 22 feet per minute. On one side may be seen the cutting tool, consisting of five drills, attached to the piston, the stroke being dealt directly by the steam pressure in the cylinder. In ten hours one of these machines has cut in Dorset marble, channel 30 feet long and five feet deep. a In this manner the entire quarry floor is cut into strips, a channel being also made at each end. One of the strips is then cut up into key blocks, viz., blocks channeled all around.

[illegible]

[illegible]

[illegible]

A Corner of the Plateau Quarry, Norcross-West Marble Co. Sullivan "Class 6½" Channelers.

Three 42-ton Blocks from the Plateau Quarry.

...and on the reserve of the Mass Mutual Life Bldg. at Springfield, Mass.

...in many months.

The company is now furnishing the...for the...of the...Co., ...of Commerce, Ha... Co., ...& R. Boring, Washington, D. C., ...office of the Agricultural Nat... Bank, Hartford, Mass., ...Power Co.

Bldg., Boston, Mass., ...John Hay Memorial Library, Brown University, Providence, R. I.

Among other buildings in which Diamond Machines have been used are the Riverside Bank, Riverside, Ill.; Texas State Hotel, New York; Water Filtering Works, Worcester, Mass.; ...Wall Insurance Building, Chicago, Ill.; Masonic Temple, Chicago, Ill.; Methodist Episcopal Church, Evanston, Ill.; Bldg., Baltimore, Md.

A DEEP DIAMOND DRILL HOLE

...In recent years ...have taken up the...prospecting and ...of the ...in the ...the discovery of ...has led to the fact that Lake ...have become largely interested in the development of Arizona copper properties and no diamond drilling is an article of faith in the Michigan copper ...to use in the newer fields has resulted naturally. Even in the ...of Michigan experts ...some of the older companies had ...diamond drills for many years. The first diamond drill ...in Arizona was ...at Bisbee ...twenty years ago. ...was ...a ...machine ...requires ...water, a ...which at ...is ...supply ...in the United States better ...that the Copper Queen ...to the ...of its property ...that under ...and that ...a test per ...This ...has ...to the ...of diamond drills.

The latter companies have ...diamond drilling from the ...to ...the best place for their shafts ...from under ground to prove up the ...location and extent of the ...bodies. The results gained have given ...and continued proof of the ...of diamond drills for exploring work.

The most recent ...of drilling ...has been on the property of the ...Water Power & ...Co., ...a ...Diamond drill ...a hole ...inches in ...to a depth of ...feet, the ...ever ...in the United States. The ...was ...from ...on the ...level ...Bisbee and the ...Junction, a ...of ...Bisbee ...The ...was ...and ...the ...ground ...per day. ...was ...and ...required ...the drilling.

The ...used was a ...Diamond ...engine, ...by ...having a ...of ...and ...a ...The ...was ...to ...a ...hole, ...to ...a ...and ...have been ...The ...must be ...and the ...

The Diamond Drill Plant

torily, however, the only trouble caused by the severe overload being the breakage of a gear stand, which was easily remedied.

THIS HOLE WAS STRAIGHT

The drilling of this deep hole involved some interesting features. Diamond drills have received more or less criticism from time to time on account of the deviation of the hole from its true course under certain conditions. Some writers have gone so far as to say that drill holes would deviate in any case, whether conditions outside of the drill were favorable for this action or not. Others devote much space to the subject of deviation and of methods for measuring it. This particular borehole was perfectly true from top to bottom. At its completion it was tested several times with a clinometer, consisting of a closed glass tube about half full of hydrofluoric acid. This instrument was placed in a metal tube, carefully sealed to exclude water, and lowered in the core barrel to the foot of the hole. After waiting a half-hour or longer, it was removed. The acid in each case etched a horizontal circle onthe glass, showing that the tube had maintained a vertical position.

The time required to hoist or lower the rods at the final depth was two hours and one quarter. The rods were pulled 20 feet at a time, by means of a single sheave, and lowered with the engine. In the course of the year's work five $\frac{5}{8}$-inch first quality steel ropes were worn out. A timber derrick 36 feet high served to pull the rods. For the first 580 feet the drill bits had to be reset about every 8 feet. Below that depth more favorable ground was reached, so that a size "A" bit ran for 30 feet, on an average. Eight carbon were used, being set with $\frac{1}{64}$-inch clearance. Care in setting the bits evenly and with a small clearance was probably responsible for the success of this hole. It has often been noted that excessive clearance results in more or less serious deviation. In fact, in the case of a number of deep-bore holes in South Africa, in which serious deviation from a true direction occurred, it was observed in each instance that the diamonds had been habitually set with an excessive clearance.

Mr. Hoval A. Smith, manager of the mining company, gives the following information regarding the progress of the work:

Standpipe was driven through 38 feet of surface drift, and the casing secured by drilling it 4 feet into the rock. Soft ground was encountered at several places down to 580 feet. Instead of reaming out the hole and casing it, to overcome the trouble, the cementing method was employed. After drilling as far as possible in the soft ground, cement was pumped down through the rods, the rods pulled, and the cement left to harden until the next day. This cementing kept the hole tight, and secured return water as far as 580 feet. In the lower part of the hole the water gradually decreased and at last failed to return at all.

A Sixty-foot Steel Derrick in South Africa, over a Sullivan "P" Drill, boring a 5,382 foot hole.

New Four Track Line of the Erie Railroad through Bergen Hill.

Profile of the Four Track Line through Bergen Hill.

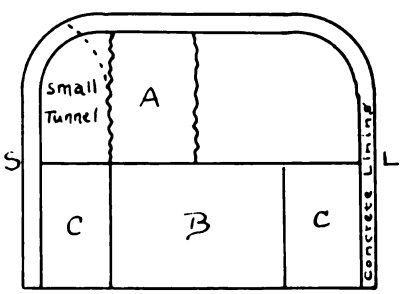
Starting the Shaft near Hoboken Ave. with Sullivan Drills, March, 1908.

in the open cuts, vertical holes only are used, breaking the ground from the top of the cut. These holes are drilled from 14 to 16 feet in depth. The air reaches the drills at about 90 pounds pressure.

The steel has a finishing gauge of 1⅜ to 1½ inches, and regular cross bits are used, formed and sharpened on a machine drill sharpener. Owing to the extreme hardness of the rock, the wings or corners are maintained for about an inch back of the face, to prevent rapid wearing of the gauge.

The powder used is 1¼ inch, and all shots, both in the open cuts and in the tunnels, are fired by blasting batteries, according to eastern practice, instead of spitting the fuses by hand, as is customary in western mining tunnels.

The cuts on pages 278 and 282, show the tripod drills in operation, and the nature of the rock encountered. Rock fragments too large for the crushers are broken up by block holes from one to two feet deep. These holes are bored with Sullivan "D-19" hand feed air hammer drills, using hollow steel (see page 284). These drills weigh 30 pounds. A part of the exhaust is directed through the hollow steel to clean the holes, and rotation is secured by a hexagonal drill shank and bushing, the drill and steel being turned by a wide double-grip handle. This has proved a very economical way of handling this part of the work.

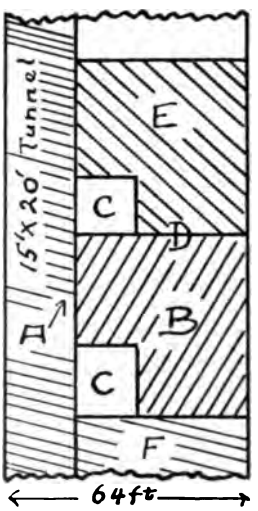


Cross-section of Tunnel.

TUNNELS

All the tunnel sections have a width of 64 feet. They are driven according to a special plan, made necessary by their great size. Headings are first carried above the spring line, and on the wall farthest from the old tunnel, to avoid danger to traffic. Page 281 shows the entrance to one of these headings. They are next enlarged into tunnels 15 x 20 feet, as shown by the sketches, on this page. The portal of the main tunnel is then carried in full section for 15 or 20 feet above the floor line of the small tunnel. The drills are now mounted on columns at "A," and the shaded portion "B" removed, leaving a supporting pillar "C." (Second sketch.) The drills are again set up at "D," removing section "E," and again leaving a pillar. This process is repeated until the whole heading is widened. The benches "C," are then excavated, leaving a core "B," 20 to 30 feet wide, to support the pillars and the additional wooden props which are needed. (First sketch.)

At this stage the first section of concrete lining will be placed, extending up to the



Plan of Tunnel at Spring Line.

West Portal of 15-foot Tunnel under St. Paul's Avenue.

llar. This lining will be left to
while the concrete crew is at work
other tunnels. The first pillar and
s "B" will then be removed, as
pillar number 2, the walls and roof
with concrete, and the work con-
in this order of rotation.

iving the headings, four Sullivan
" drills are used, two each being
ed on eight-foot double screw
s. The benches are taken out by
mounted on tripods, which remove
grade line in two lifts.

DISPOSITION OF SPOIL.

broken rock is handled by movable
s at the faces of each heading, and
imary ones at the surface. Two
shovels are in constant use. Over-
aideways are suspended across the
many points, operated by stationary
plans or electric motors at the sides
cut.

A three-foot gauge track runs on the surface the full length of the cut, for removing the spoil. A temporary tunnel under Hudson County Boulevard prevents interruption of traffic there. The earth is carried to the Hackensack meadows for embankments, and the rock is hauled to a large crushing plant at the western end of the work. One hundred and twenty-five four-yard dump cars and eight industrial locomotives are used for this purpose. Page 283 shows the character of the work from St. Paul's Avenue west to Hudson County Boulevard, marked by the stone wall in the background. The ruined building at the left is an air shaft for the old tunnel, and shows how close the two lines are to each other. The two rails shown have been carried down to grade, leaving only the central 30-foot strip on which the derrick is placed.

Shaft between Summit and Central Aves. This cut shows the very blocky character of the rock.

Looking West from St. Paul's Avenue to Hudson County Boulevard.

ge 284 shows the large stone pile, over
eet wide at the base. The rock is
ed, by an air cylinder, into a No. 10
er, whence it passes to four No. 6
ers, which reduce it to 2½-inch
It is then carried to the stone pile
450-foot belt conveyor, which rises
height of 75 feet. The stone is dis-
ed by a stacker and another adjus-
conveyor, with a travel of 700 feet.
ge part of this pile has since been
ed for use as ballast on the Erie's
ked.

POWER PLANT

e power house, compressor plant,
epair shop are also at this point. A
ense power cross-compound engine
the crushers and conveyors, except
on the stone pile. The three cross
mpound air compressors deliver air for
70 drills to a riveted pipe line run-
the entire length of the work. The
plant consists of four 500 horse
power water tube boilers, equipped with
a feed water heater, and a fan for forced
draft.

PRESENT STATE OF THE WORK

The work of excavation has been somewhat slower than usual on such undertakings, owing to the precautions taken to avoid accident to the old tunnel. Until recently, blasting was permitted at only three times in the 24 hours, when the traffic was at its low points. When permission to blast was given, no trains were allowed to enter the tunnel until the shooting was over, and until an inspection car had been run through the tunnel to make sure that the walls were not affected. Blasting is at present allowed at any time.

The open-cut excavation is now (February 1) about half completed, and the tunnel work about 25 per cent finished. All of the small preliminary tunnels are done, and the widening to full section of the tunnel above their floor line is finished

The Crushed Stone Pile and Conveyors.

Sullivan "D-19" Foot-hole Drills, Block Holing on the Erie R. R. cut, Bergen Hill.

in the tunnels under Hoboken, Central and Summit avenues. It is progressing rapidly under Hudson County Boulevard and St. Paul's Avenue.

The Millard Construction Company were fortunate in securing the services of Mr. John Hendrie as their superintendent on this work, as he has had a very wide experience in tunnel and open-cut work, especially in railroad contracting jobs. Having had charge of the western section of the new Pennsylvania R. R. tunnel, recently completed through Bergen Hill, he is extremely well posted on the peculiar nature of this rock and the difficulties to be overcome.

The writer acknowledges to Mr. Hendrie assistance rendered in preparing this article. Some of the general data and sketches which are used first appeared in the Engineering Record of April 18, 1908.

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Volumes I III

Sullivan Class "WC" Air Compressors

require smaller boiler capacity, i. e., burn less coal, than any slide-valve compressors of like size : full Corliss Valve Gear on both high and low pressure steam cylinders make these machines the equal in fuel economy, of the best class of Corliss cross compound compressors.

The air is compressed in two stages, with a large intercooling area.

"WC" compressors cost less to build, transport, and house than cross compound machines, on account of their tandem construction.

If you wish further demonstration of the fact that Sullivan Tandem Compound Corliss Two Stage Compressors furnish air power at a lower cost per cubic foot than any other steam driven machine, send for Bulletin No. 158-D.

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MINE AND QVARRY

643305

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SULLIVAN MACHINERY COMPANY

ANNE McCARRY

One of the West Rutland Covered Quarries.

A Covered Quarry, from the inside. Sullivan Steel Channelers in foreground, Diamond Channeler at left.

The deep Sutherland Falls Quarry.

and cheaply than by hand. With this invention, production grew apace, and became more of a mining than a quarrying operation. The reproduced photographs on pages 286 and 291 show how small some of the openings are, and the other pictures in this article give a further idea of the magnitude of the workings developed by this process. Page 294 indicates the characteristic method of opening one of these quarries. Here a square shaft has been carried down to the beginning of the good stone, and tunnel cuts are being driven from this point in all four directions. The quarry floor, in the meantime, is cut up into blocks by cross channels.

The Vermont Marble Co. still owns 20 Sullivan diamond channelers, but their use has gradually diminished with the advancing price of diamonds, due to the widening application of the diamond core drill.

STEEL CHANNELERS

About 1888 or 1889 the Sullivan swivel head direct acting single gang steel channeler was perfected by Mr. Albert Bull, and since that time has remained with various improvements in details, the standard marble quarrying machine in Vermont and elsewhere. The Vermont Marble Co. now owns about 80 of this type, out of a total of 104 steel channelers.

The Sullivan marble channeler has a 65½-inch cylinder, and is able to cut at any angle from vertical to horizontal, in the usual direction, i. e. at right angles to the line of the track.

The diamond channelers were unable to swivel in the same plane as the cut, to channel into the sloping walls at the end of the floor, or to cut out corners. The steel channeler, however, may also be extended on its frame to cut into walls or corners, at any angle up to 27½ degrees, or to 72 degrees, by adding special bracers. The machine is too well known to quarrymen to need further description here. A recent labor-saving improvement consists of a set of sprockets and a chain for running up the feed screw by power instead of by hand, when necessary to change steel. The accompanying cut shows the standard marble gang bit of five pieces.

At Pittsford, Vt., one of these channelers has cut over 5,800 square feet in a 60 days' test run, and 5,400 feet in 30 consecutive days, at Pittsford and Proctor. Monthly records of individual machines at one of the West Rutland quarries, made several years ago, were 2,652 feet, 2,649, 2,287, and 2,449 feet, while the record of eight machines for one month showed an average of 1,846 feet.

QUARRY METHODS

The West Rutland quarries represent the typical methods employed in the district, and more detailed mention of them may be in place. There are seven or eight of these openings in the hillside, on an incline of 15 to 45 degrees, pitching east, and following the hill for about 3,000 feet. Several of these are connected by a tramway along the bottom floor, and blocks are handled by a motor car to an incline, upon which they are run to the quarry bank. The deepest of these quarries has reached a depth of 200 feet vertically, and from the open pit, angle

Sullivan Diamond Channeler.

A Sullivan Improved "Class 6^1_2" Channeler making a tunneling cut at West Rutland. The roof is about six feet high. (From a flash-light photograph.)

cutting or tunneling has been carried on to the east some 200 feet, and to the west nearly 300 feet. The workings have never reached the limit of the deposit of marble in either direction, as indicated by prospecting with a Sullivan Diamond Core Drill.

The cut above shows a Sullivan channeler making an angle or tunneling cut 9^1_2 feet deep. This machine is between 200 and 300 feet from the open pit, and the picture was taken by flash-light. The roof here is about six feet high and the cut, when completed, will come down to the level of the quarry floor. The method employed in this quarry for increasing the producing area in the covered portion is shown by the rough sketches on page 292

No. 1 corresponds to the photograph above. When the cut made by the channeler is completed, the track is moved along the floor and a new channel started. An unbroken line of channel, at times 100 feet in length, is put in, and as the channeler is moved along, the worthless marble or cap rock is blasted out so that the work of channeling is not interfered with. In the center of this sketch is shown a channel cut, indicating the method of extracting marble as the floor advances. At the left is a quarry bar with a drill, which shows the way in which this tool is set up for drilling the bottom holes. A special rock drill is used for this purpose, with the steam chest on the side, so that the drill can put in holes, which are practically at the floor line.

Figure No. 2 shows the method of drilling the holes to complete the removal of the face of worthless rock begun

Sullivan "Gad" Channelers at Proctor, Vermont.

by the channeler. The bottom hole is fired first, removing the stone between the floor and the channel cut. The second line of drill holes, above the cut, is then placed, and the rock removed before the roof holes are shot. When the new face is opened up the channelers are again put to work, and in the meantime, the quarry floor is advanced by the bench system, as shown in the sketches. After the longitudinal and cross vertical channels are made in the floor, and the bottom holes drilled with quarry bars, a vertical line of holes is drilled at proper intervals, as shown in sketch No. 2, either with a gadder or quarry bar, to split the blocks up into suitable sizes for handling. These blocks are split off from the main layer by means of "plug" and "feather" wedges. A chain is then placed around the block, and it is hauled out to the open pit by means of a stub derrick, so that the derricks on the bank can raise the blocks to the surface. The stub derrick is advanced from time to time so as not to have too long or too flat a haul for the blocks. The company has, at its various quarries, 65 Sullivan drills, bars and gadders, and 77 block derricks and traveling cranes. In drilling the gad holes for removing the blocks, as above described, throughout the district, the flat bit with diamond point, as shown in figure No. 3, has until the last few years been the standard method of sharpening the steel. Many of the quarry-men have more recently taken up the cross bit with diamond point, which is generally recommended by drill manufacturers for quarry purposes. The objection to the flat bit is the difficulty of securing proper rotation for round holes. In marble, only a minute or two is needed to put in a hole two or three feet deep, with one of these drills. The work done with each stroke of the drill is considerable and creates a tendency to form lumps in the hole, so that there is a large amount of wear on the

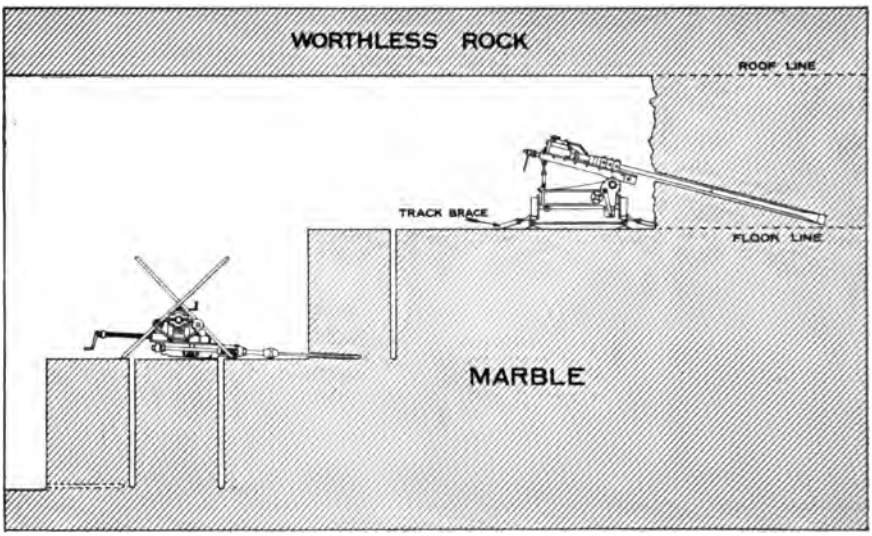


Fig. 1.

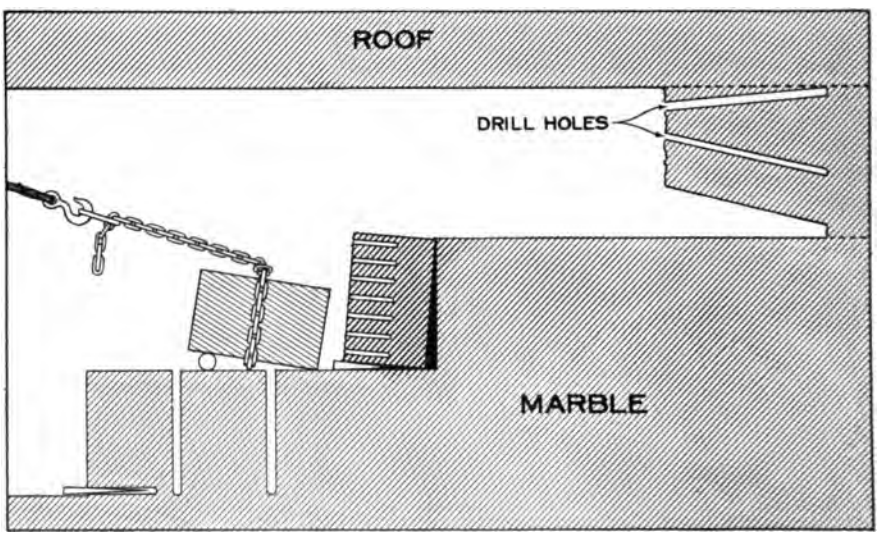
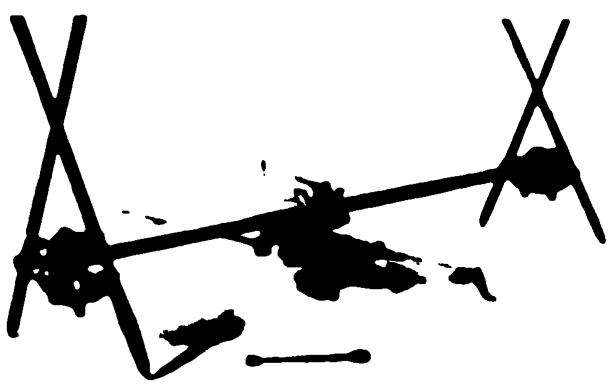


Fig. 2.

rotating device, and also frequent sticking of the bit in the hole, which causes delay and cylinder wear. These objectionable features are altogether eliminated by using the cross bit. The progress may not be quite as rapid in one or two given holes, but in a day's work or week's work, the amount of drilling done with the cross bit will equal, if not surpass, that accomplished with the flat bit, while the wear and tear on the drill is greatly reduced.



A new opening, showing the beginning of angle cutting.

maintains its own machine shops at Proctor and West Rutland for making repairs to its equipment. Power for the channeling machines and drills is furnished by steam boilers at the different quarries. An interesting feature of the marble mills is the method of securing sand for the gang saws. This sand is brought over the hills from Pittsford by an aerial tramway, two miles in length, on electric power furnished from Proctor. It is carried in buckets, which average one to every thirty feet of cable.

A visit to the quarries is one of the great interest for even the layman. The location of the industry is one of physical beauty which it would be difficult to equal anywhere in this country. The deep valleys and abrupt hills of the Green Mountains, heavily wooded, furnish a wonderful background for the white marble pits and acres upon acres of blocks and slabs. The country roads in this part of the state are paved with crushed marble, the sidewalks are made of marble slabs, and to one unaccustomed to seeing this valuable stone, except in monuments or buildings, there seems to be a lavish use of it, which is almost wasteful. In visiting the quarry pits, the traveler who is sufficiently inquisitive, is led down a steep ladder, some 100 or 200 feet, to the bottom of the quarry, or to a hole in the side of the hill, into which it is difficult to see more than a few feet, on account of the steam. In this atmosphere, the electric arc lights are merely an aggravation of the gloom. One is told that in this quarry there are "about 12 channelers," but he could not believe it, except for the deafening roar which he knows must come from the blows of the steel and the exhaust. Nothing short of a photographic flash-light will reveal these busy machines and their operators, until the visitor is almost near enough to feel them as well as see them.

One could spend days in visiting the various mills and finishing shops, following the stone as it comes from the slow and ponderous gang saws to the polishing beds or planers, or is carved and molded

Bullfrog Side-hill Channelers with balance cars on a steep slope at Proctor.

under skilled hands into delicate forms. Machinery does many wonderful things in these plants, one of those amusing to the novice being the turning of an oval hole in a washstand slab without hand labor.

LABOR CONDITIONS

The ability and keen insight of the late Senator Redfield Proctor and his son, Fletcher D. Proctor, who has recently finished a term as governor of his state, have made this industry what it is to-day. From an economic view, one of their most interesting and valuable achievements is their solution of the labor problem. Many of their employes are of foreign nationalities, but labor troubles are few and far between.

For a number of years the company has maintained company stores at Proctor, West Rutland and Center Rutland, and since about 1905 all profits made have been divided among its employes. Each employe who buys goods at the store receives at the end of the year a cash dividend based on the profits of the business and the amount of his purchases. Non-employes receive no dividends from their purchases. In one year the sales at Proctor alone amounted to $250,000, and the net profit to $20,000, after deducting all expenses, including four per cent. interest on the money invested in the business by the company. The Proctor employes received rebates of eleven per cent. on their purchases, those at West Rutland, ten per cent., and those at Center Rutland eight per cent. The sales to buyers other than employes at the three stores amounted in that year to $115,000.

The company has built a handsome marble club house for its employes at West Rutland, a Y. M. C. A. building, a library and a hospital at Proctor. Much of the hospital service is rendered gratis, while the rates charged are so low that the actual income from paying patients amounts to only a small percentage of the running expenses. A free visiting nurse organization is also maintained.

A list of the structures, monuments and

The 60-ton Crane at West Rutland.

General View of Proctor; Finishing Works in Center.

Map Showing Position of Cobalt and New Districts in Ontario.

Courtesy Mining and Scientific Press

leads have, upon exploitation at depth, proved to carry silver.

On account of these numerous barren leads, which are usually nearly vertical, diamond drilling, both from the surface and underground, is also extensively employed and has done much for the development of the district. Another valuable service performed by diamond drilling is to test the formation without regard to values, as surface indications are often misleading and the development of the camp has shown that diabase, in many parts of the area overlies the lower Huronian formation, in which fully 90 per cent. of the important producing veins have been found.

The drill holes are usually put in at angles ranging from 10 to 45 degrees, to depths of 150 to 400 feet, to test the persistence of the surface showings. The rate of advance varies from 5 to 8 feet per shift. The Sullivan H, Beauty, and S diamond drills are the styles most frequently used for this work, the first removing a 1⅛ inch, and the last two a ⅞ inch core. These machines are compact and readily moved from place to place. Roads are few, and the country is rough, swampy, and, before clearing, covered with thick timber and bush. This page shows a Class C drill outfit set up on the property of the O'Brien Mining Co., for drilling an angle hole from the surface. An S diamond drill underground is illustrated on page 299. The overburden encountered in surface prospecting is light so that but little drive piping or casing are needed. There are now about 17 diamond drill outfits at work in Cobalt and vicinity.

MINING METHODS

Mining is carried on in the usual manner, drifts usually five feet wide by seven feet high being driven on the veins at the different levels.

The rock is exceedingly hard but breaks well, and 3¼ inch air drills are commonly used. An average of 30 to 40 feet of holes per shift is considered satisfactory drilling.

From 9 to 14 holes are required to

Sullivan "C" Diamond Drill on an angle hole at the O'Brien Mine.

Sullivan "B" Diamond Drill at work underground.

make a five-foot break in a five by seven-foot heading. No timbering is required for by sealing off the loose rock from the walls and roof as the drifts and cross-cuts advance, later falls of rock are almost entirely avoided.

Overhand stoping is very widely employed for extracting the ore. Stulls and timbers are set in the drifts, with chutes every 15 feet, from which the ore and muck are drawn only fast enough to give space for men to work in stopes on top of the muck.

In some cases, in addition to values in the vein itself, native silver is shot into the wall rock and appears in leaves and slabs of various sizes. In such instances the stopes are carried wide enough to extract all the mineral bearing rock. Usually, however, the values are confined to the vein, and the stopes are carried as narrow as possible, that the handling of barren waste rock may be reduced to the minimum. Here the Sullivan air feed D-21 hammer drills are found to be admirably adapted to the work in hand, and with them, stoping can be conducted at a cost of 25 to 30 per cent. of that sustained when reciprocating drills are used; these necessitating wider places in which to be set up and operated. The cut on page 300 shows a stope and the drills referred to.

POWER EQUIPMENT

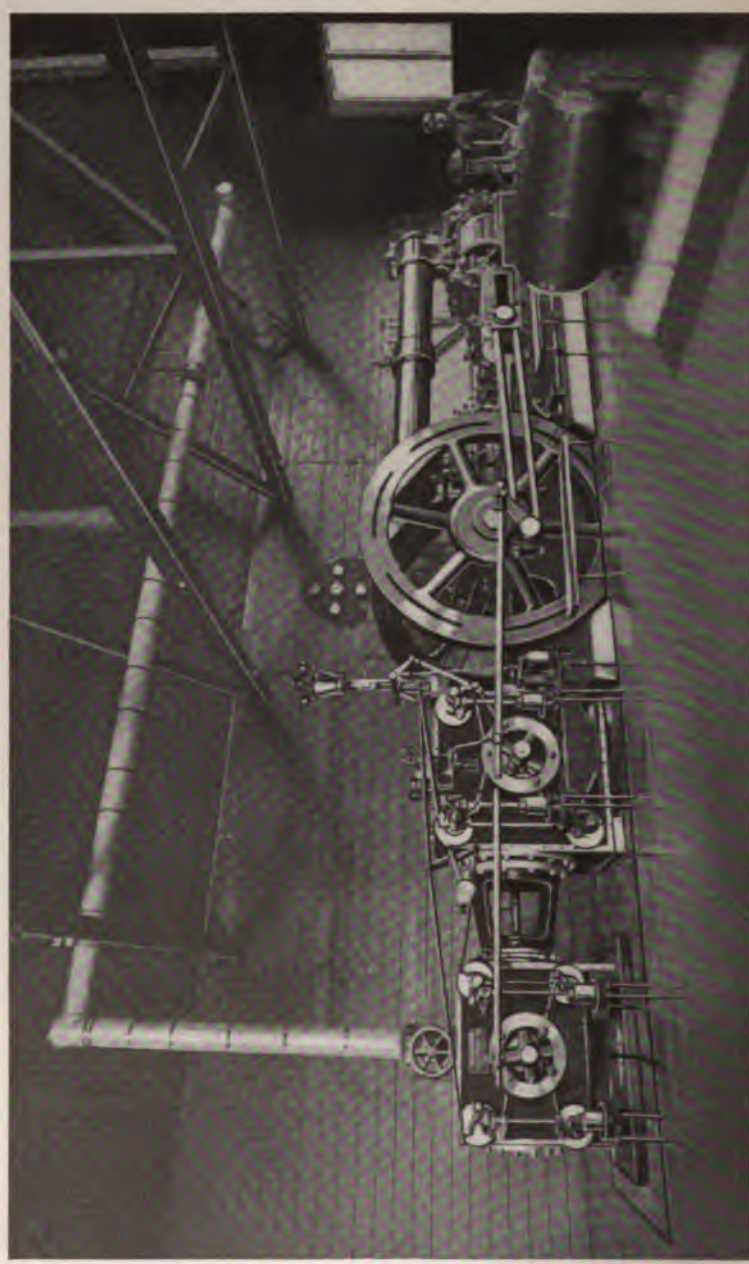
Coal for hoisting engines and air compressors is brought from the United States at a cost of $6.00 to $7.00 per ton, depending on the length of haul and the condition of the roads. For this reason much attention has been given in the camp to the economical production of power. The first air compressors installed were inexpensive, single stage machines, of low first cost, but relatively high steam consumption. More recently a number of two-stage air and compound steam compressors have been placed in service. A type which is receiving some favor, is the Sullivan

Stoping with Sullivan D-21 Hammer Drills in the La Rose Mine.

"WC," a compressor with tandem ...nnel Corliss steam cylinders and ...ge air cylinders, as shown in the ...ration of the machine, on page 302. ...d by the Temiskaming Mining Co. ...Corliss valve gear on both steam ...ders secures first-class operating econ... while the design of the machine, ...ing that of the straight line type, ...s a cost of manufacture, trans... ...on, and installation very much lower ...e possible in the case of Corliss cross ...nnel compressors. The Temiskam... ...achine has a rated capacity of 1843 ...feet of free air per minute, at 100 ...lb. Other air compressors of this ...e in the camp are owned by the Crown ...ve Mining Co., Ltd., a photograph ...ose surface workings is shown be... the Kerr Lake Majestic Mines Co., ...and the City of Cobalt Mining Co.

There are also a number of the ...ies standard, two-stage straight ...compressors, Class "WB-2," in the ... The Cobalt Hydraulic Power ...l local enterprise, is constructing a Taylor Hydraulic Air Compressing plant on the Montreal River, at Ragged Chutes, where a fall gives a good head of water. It is the plan of this firm to *supply* air power to the entire district at very low rates, since the only expenses involved are those of construction and of pipe lines. The rock shaft and compression chamber which form the principal elements in this system, are being constructed with the aid of a Sullivan belt-driven air compressor, Class "WJ," and Sullivan 3½ inch drills. Compressed air will be ready for delivery on August 1, according to the *Mining and Scientific Press*, which says:—"To bring the air to Cobalt nine miles of 20-in. pipe will be laid. The loop-line will start from the end of the La Rose bridge and will encircle the town, joining with the main line afterward. In the loop and the various branches around Cobalt the pipe will be 12 in. In addition to the loop there will be branch lines by way of the Colonial and the Nova Scotia. Another line will run to Kerr Lake. A pressure of 110 lb. per square inch will be maintained and the following rates per

Plant and Office Building, Crown Reserve Mining Co., Limited.



Sullivan Class "WC" Air Compressor of the Temiskaming Mining Co., Cobalt, Ont.

The Mouth of the Tunnel.

DRIVING THE MAUCH CHUNK TUNNEL

WRITTEN FOR MINE AND QUARRY BY L. R. CHADWICK*

What is probably the most extensive natural drainage system ever contemplated in the anthracite coal region has been undertaken by the Lehigh Coal & Navigation Company, for the purpose of draining the workings in the Panther Creek Basin. This basin lies between Locust Mountain on the north, and Sharp Mountain on the south, and extends from a little west of Mauch Chunk, Pennsylvania, on the east to Tamaqua, Pennsylvania, on the west. It is about 12 miles long by 2 miles wide at its widest part, and takes its name from Panther Creek, a small stream flowing toward the west and joining the Little Schuylkill river at Tamaqua.

The western end of the Panther Creek Valley workings have been drained through a water level tunnel into the Little Schuylkill river, but many of the workings are already much below this drainage level, and with increased depth the cost of pumping would steadily increase. At the eastern end of this basin, the Lehigh river is some 300 feet nearer tide level than the Little Schuylkill at the western end, so a system of connecting tunnels and gangways has been decided upon which will carry water from the workings to the Lehigh river, thus bringing the drainage level considerably lower. By this means a large territory of coal yet to be worked can be drained naturally, and the cost of pumping water from the lower workings will be materially lessened.

The outlet of this system will be through the Mauch Chunk Drainage Tunnel. This tunnel starts from the Lehigh river just above Mauch Chunk, and will be driven through rock for a distance of about 7,500 feet. At this point it will meet a drainage gangway in the coal which with other connecting gangways and tunnels, will give a continuous drainage way throughout the region, the total length of which is estimated at nearly fourteen miles.

When the Mauch Chunk tunnel was started considerable difficulty was experienced, as for the first 300 feet the ground was soft and timbering necessary. The Portland Contracting Company of Pottsville, Pennsylvania, took hold of the work when the tunnel had progressed about 1,500 feet, and have carried it along

*42 Broadway, N. Y.

The tunnel breast, showing drills and mountings.

steel plates are placed on the floor of the tunnel to catch the broken rock as it falls, and make shovelling easier. Then the fireman and his helper load and fire the holes, and the work is ready to be taken up by the other shift. These operations take about 12 hours.

The men live together in a house near the tunnel, and one shift is always ready to go to work when the other shift is through, no matter what the time of day. In this way no time is wasted and the work is progressing during the whole of the 24 hours.

The tunnel is at present in about 6,800 feet. It is being driven with Sullivan "UH" 3⅝ inch differential valve drills, on two double-screw, mining columns. Drills of this make and type have been used exclusively by the contractors during the two years of their work at this point, and in low repair cost and high efficiency, they have proved themselves altogether equal to the demands upon them, and entirely satisfactory in every way.

We acknowledge with thanks the assistance of various members of the Portland Contracting Company in the preparation of this article.

Central Power Plant, at Gary, W. Va.

Town of Gary and Ovens at No. 1 Mine.

COAL MINING AT GARY, WEST VIRGINIA

Written for "Mine and Quarry," by John S. Walker, Jr.*

The United States Steel Corporation, in its search for high grade coking coal, to meet the constantly increasing demands of its numerous plants, some years ago leased fifty thousand acres in McDowell County, at the southern extremity of West Virginia. These holdings are on the Norfolk and Western Railway, about ten miles from Welch, and are in the clearest part of the Pocahontas field, along Tug River and Pinnacle Creek.

In 1902, prospecting and development were begun under the name of the United States Coal and Coke Co. The property was very thoroughly tested with diamond core drills, to prove the thickness and continuity of the seam, and to determine the best locations and methods for openings. The town of Gary was established as headquarters and shipping point, and under the direction of Colonel Edward O'Toole, general superintendent, and Mr. H. N. Eavenson, chief engineer, a thriving community has been installed in this mountain wilderness.

There are now twelve mines in operation, all fully equipped with the most modern and efficient machinery. During April of this year the production averaged about 9,000 tons per day. If this coal were all mined from one spot or working face, it would cover one acre in area per day.

At eight mines the company has erected large blocks of bee-hive coke ovens, numbering 2,151. About half the coal is made into coke at Gary, the remainder being shipped raw and coked at its destination. Most of the product is sent to the Illinois Steel Company's works at Joliet, and South Chicago, Ill., while a portion goes also to Sharon, Pa.

SYSTEM OF MINING

The company mines the No. 2 and No. 4 Pocahontas seams, which range from 4½

*Huntington, W. Va.

The Sullivan Machine on Power Truck.

Sullivan Electric Machine making rib or sumping cut.

Sullivan Electric Chain Machine crossing the face of a room from left to right, under its own power.

SURFACE PLANT

photograph on page 312A shows the at No. 10 mine, which is typical of in general use. These structures uilt of steel, with modern devices andling the coal as it comes from the . Coal for the ovens goes through ers and then into large storage bins, which the coke larries are charged. ouch tipple there are also steel chutes ading into the railroad cars. The are equipped with large doors and gratis to permit the use of coke- ng machines. Twelve of these are pulling about 65 per cent. of the from the company's ovens.

ventilating fans are of the most st type, adequate for forcing air to extreme limits of all the workings. e substantially set in solid concrete ings.

POWER EQUIPMENT

central power plant from which all f mines are operated, is at Gary, ing Mine No. 2. The boiler house ins nine horizontal, water-tube boil- ving a total horse power of about . The furnaces are charged auto- ally by underfeed stokers, supplied overhead steel bins.

the engine room are two 400 kilowatt rators direct connected to cross com- Hamilton engines and two 750 watt generators, direct connected to Hamilton-Corliss cross-compound en- ; also one 1,000 kilowatt low pres- and one 1,000 high pressure turbo- ator, the former taking its steam from the reciprocating engine ers.

ese units generate three-phase, 25 cle alternating current at 6600 volts, is transmitted to sub-stations at mines, and there altered to 275 and volts d. c. for the mining machines, s, and locomotives, by rotary con- rs and transformers.

machine and forge shops are well ped with modern tools for electrical machine repairs, insuring the rapid and economical work essential for a large industry such as this, far from a source of supplies.

The company's offices, general store, power station and shops are large per- manent stone buildings, with ample pro- vision for growth.

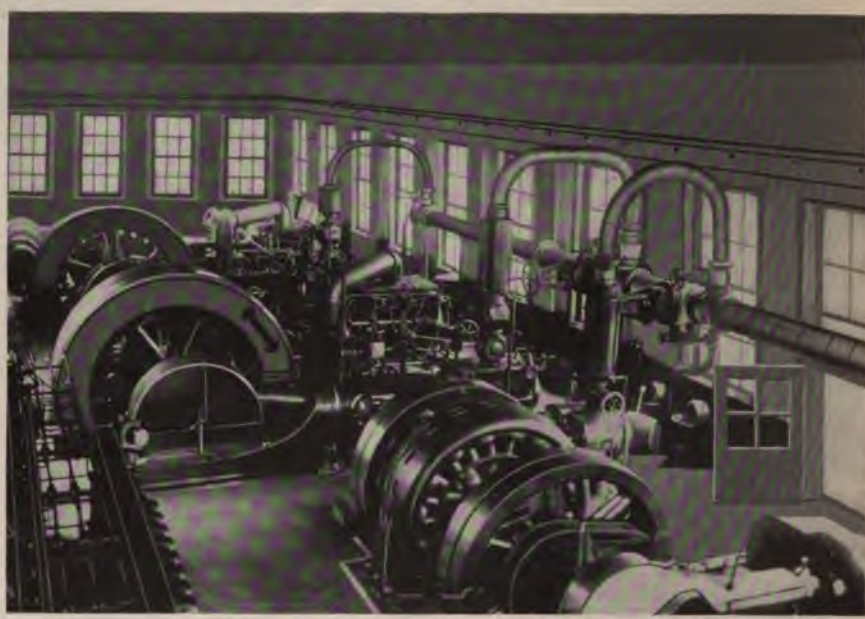
The town of Gary is well paved, lighted, and has excellent water and sewer systems and fire protection.

LABOR AND SAFETY PROVISIONS

About 3000 men are employed at the various mines, including a construction force of 300. The employees include Ame- ricans, foreigners of several nationalities, and negroes, who live, to a large extent, in substantial houses built and owned by the company.

The U. S. Coal & Coke Company en- joys the distinction of having the best equipped and safest mines in West Vir- ginia. Under the administration of Mr. Thomas Lynch, president of this company, as well as of the Frick Coal and Coke Co., a remarkable record of freedom from acci-

Sullivan Machine unloading from Car Truck.



Interior of Central Power Plant.

dent has been made. During the year 1907, the mines under his administration produced over 18,000,000 tons of coal, ranking them first among the coal mining companies of the world. In eighteen years these mines have not lost a life by a gas or dust explosion. At Gary, all the mines are supplied with a carefully drawn set of rules, regarding ventilating and sanitary conditions. These are printed in seven or eight languages in large type, and posted in conspicuous places. Particular attention is called to the necessity for careful handling of powder. It is required that not more than a certain number of men shall work in any one air current, and that the current shall not fall below a stipulated velocity or a quantity of 10,000 cubic feet per minute at any point throughout the entire mine workings.

The mine foremen, assistant mine foremen, and minor officials are paid premiums each month during which no one under their jurisdiction is seriously injured. Since the adoption of this method, accidents of all classes have been reduced more than one half. Premiums are also paid to the superintendents, who keep their plants in the best and neatest order, also to householders, for the best kept yards and gardens. All mine officials are required to pass a physical and mental examination as to their eyesight, hearing, and reasonable discretionary powers, before appointment to duty. In the main office at Gary a set of rescue apparatus is installed for use at the various mines in case of emergency.

The records show that in spite of the fact that the country being developed is entirely new, and the subordinate officials are strange to their positions, the number of accidents for the miners employed is the least, not only in the state, but in any other state as well, or in any other country. As was noted above, all the coal in these mines is undercut before being shot. No shooting from the solid is permitted, and men are employed to see that the coal is properly mined before

shooting, thus eliminating the great danger to life from shooting off the solid, to say nothing of the amount of powder-smoke done away with.

CORE DRILLING IN NOVA SCOTIA

Since 1903 the Department of Mines of Nova Scotia has owned and operated several prospecting core drills to further the interests of the mining industry in that province.

As this is one of the few instances in which costs of drilling work are available to the outsider, the carefully compiled tabulated reports of the department are always interesting. That for the year ending September 30, 1908, has recently appeared. The department had five drills in use during the year, two of the Sullivan diamond pattern, and three of the Calyx shot type. During the year these drills cored 22 holes for a total of 7,305 feet 7 inches, some 1,000 feet in excess of the work for the preceding year, and the largest amount of work thus far accomplished in one year.

The cost per foot for all boring by diamond drills was 80½ cents, and by Calyx drills $1.34. The carbon cost per foot in boring by diamond drills was $.077, and the shot cost per foot by Calyx drills, .036. These costs compared with last year's results were as follows:

Cost per foot, all boring, 1907, $1.23; 1908, $1.06. Decrease 17 cents.

Cost per foot, Calyx, 1907, $1.71; 1908, $1.34. Decrease 37 cents.

Cost per foot, Diamond, 1907, $.73; 1908, $.641; Increase 11 cents.

Shot cost per foot, Calyx, 1907, $.047; 1908, $.036; Increase $.009.

Carbon cost per foot, Diamond, 1907, $.0129; 1908, $.077; Increase $.041.

The article on "Test Borings for Dams and Bridges," which was announced for this issue of "Mine and Quarry," has been omitted owing to lack of space. It will appear in the next number.

Tipple at No. 11 Mine, Gary.

TEST BORINGS

Sullivan diamond drill testing a dam site on the Missouri River

¶ Exact knowledge of the location and extent of rock formations may be secured at the least expense with Sullivan Diamond Core Drills.

¶ This company makes a specialty of undertaking drilling contracts, at an agreed price per foot.

¶ In its experience of over 30 years, the company has done many thousand feet of diamond drilling in the coal measures, in many of the hard mineral districts, and on the sites of numerous dams, bridges, tunnels and other structures. Prices quoted on request. *Catalogue 155.*

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MINE AND QUARRY

VOL. IV No. 1 SEPTEMBER 1909

UTAH PORTAL POWER PLANT IN THE GUNNISON CANON

THE GUNNISON TUNNEL

VENTILATION AT AN INDIANA COLLIERY

QUARRYING MARBLE IN TENNESSEE

SULLIVAN MACHINERY CO.

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MINE AND QUARRY

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taking. In the excavations which were necessary to give the dam a solid rock foundation in the river bed, and in the blasting work in the tail race, standard Sullivan air-driven rock drills were used. In the erection of the cofferdam cribs, which are built of immense timbers spiked together, the holes for the spikes are bored with air-driven augers. The concrete mixer, consisting of eight units, each with its own engine, is run entirely by air power.

"For depositing the concrete in place along the dam there are five huge traveling pelicans, two of which have two engines each, and three, four each. Besides these, there are at work at various points along the dam five derricks of five tons capacity each. There is also a thirteen-hundred-foot cableway, capable of handling a five-ton load. The engines on all this machinery are operated by compressed air.

"In the machine shop, where the repair work is done and the spikes and bolts used in construction are made, as well as in the carpenter shop, where the cement forms are built, the power is derived from an engine driven by compressed air. An eight-hundred-pound steam hammer in the machine shop is also worked very successfully by air power.

"The advantages of this method over that of running so many scattered machines by steam are easily seen. The cost of producing the requisite amount of air with compressors of the Corliss cross compound condensing type, developing a horse-power on from 14 to 16 pounds of feed water per hour, and the resulting low fuel consumption, is much less than the cost of steam to do the same work. The loss in transmission of air power is very slight as compared with the loss due to condensation in steam pipes. An expensive system of distribution of water and coal is avoided. Individual boilers for the hoisting engines, as well as firemen to tend them, are dispensed with. Repairs on such boilers, which would be great owing to the inferior class of labor necessarily employed, are saved. The increased comfort to the men arising from the absence of heated parts about the machines, greatly facilitates the progress of the work.

"Such have been the demands of the work that since the compressors at the dam were installed in May, 1906, they have frequently had to run during the entire 24 hours for several days at a time, yet at no period has the work been held up for want of air pressure, and the cost of repairs has been practically nothing."*

The air power plant mentioned consisted of two Sullivan-Corliss cross compound steam and two-stage air compressors, having a combined capacity of over 5,000 cubic feet of free air per minute.

The McCall Ferry Dam Under Construction.

*Mine and Quarry, August, 1907

Sullivan "XB" Drills in the River Portal Heading of the Gunnison Tunnel.

THE GUNNISON TUNNEL

By W. F. J. Dennison*

On July 6th connection was made between the eastern and western headings in the Gunnison tunnel, of the Uncompahgre Irrigation Project of the United States Reclamation Service, in Montrose County, Colorado. The culmination of four and one-half years' work in driving the longest tunnel in America (30,582 feet) is thus described in the report of Mr. C. T. Pease, the Project Engineer:

"On Tuesday morning, the 6th, Mr. Daniels broke into West Portal heading with an 18-foot drill hole and at 11 o'clock a blast at the River Portal end reduced the distance between headings to fourteen feet. The crews at both headings were, of course, making every effort to be the first to break through. During the day, up to 4 o'clock in the afternoon, the crew at West Portal put in a round of eleven 10-foot holes. These were heavily loaded and fired at about 5 o'clock, in the hope that the heading would be broken down, but when the smoke cleared away it was found that there still remained about four feet of wall between the headings. Fortunately, four of the holes drilled near the center of the round did not break to their full depths. The heading crew immediately reloaded these holes as heavily as possible and fired at about 7:30. This shot so shattered the remaining wall that with the use of a pick a small hole was excavated and one of the drillmen pushed through. As the second man attempted to make a passage the crew at East Portal discovered him and in a good-natured rivalry to have one of their own crew the first through the hole attempted to drive him back with the air hose. In this they were unsuccessful. Messrs. McConnell and Hardy made their way to River Portal camp and took supper with Mr. Daniels.

* 1746 Broadway, Denver, Colo.

The Gunnison River and Power Plant at River Portal. A small cross in the left foreground indicates the tunnel entrance.

The Uncompaghre Valley, town of Lujane, and west portal of the tunnel.

the metamorphic granites which constitute the main body of the mountain."

Much of this granite was exceedingly hard and tough. In the River Portal heading, 10,000 feet long, it was necessary for all supplies and material to be handled through one opening. From this came all ventilation, except that provided by the drill exhausts, and through this all water encountered, and there were enormous quantities of it, had to be pumped, owing to the down grade from the portal.

Through the greater part of its length the tunnel was driven on the bench and heading system, but about a year ago extremely large quantities of water were encountered in the River Portal, so that much larger pumps had to be installed and the expense of driving was greatly increased. On this account it was decided to change the method of driving to an under-cut, leaving the top or back to be taken down later. By this means the lower part of the tunnel has been completed in the shortest possible time and the water met in the River Portal end now flows by gravity from the tunnel through the West Portal, and the expense of pumping is done away with. It now remains for the top to be taken down, bringing the tunnel to its full size, and to put in the concrete lining in that portion which has not already been so lined.

DRILLING RECORDS

During the construction of the tunnel, Sullivan Drills have been used almost exclusively in the hard rock. At first Leyner drills were used on the River Portal heading and Jeffrey Coal Drills on the West Portal heading, where extremely soft shale was encountered. Later on Sullivan 3-inch piston drills were used on the River Portal heading and have been used continuously ever since. On the West Portal, after harder rock was reached, Sullivan Class UB 2½-inch piston drills were used for some time, and later on replaced by Sullivan Class UD 3-inch drills as the rock grew still harder, and later still Sullivan Class UF2 3¼-inch drills were used in some of the hardest rock. To quote again from Engineer I. W. McConnell:

"Some very creditable progress records have been made. In the twelve months ending July 1, 1906, Superintendent Higbee drove 7,500 feet of tunnel with one gang composed of three shifts, working in shale. The greatest progress in any month was 824 feet of heading advance, which, so far as the writer is informed, is the greatest advance ever made in tunnel driving.

"In 1905 Superintendent Knowles drove 384 feet of under-cut drift in one month in granite rock. One year later, in the same material, Superintendent W. H. Davis drove 392 feet of full-size tunnel in a month. Some months later Superintendent H. L. Daniels drove 449 feet of heading advance in one month, which at the time was the American record in tunnel driving. In March, 1909, Superintendent L. A. McConnell drove over 400 feet of heading. Superintendent A. F. Ross laid out and installed the power plant at the west end under adverse conditions. Afterwards he carried to successful conclusion the difficult and dangerous work in the fault zone.

"In a general way 300 feet per month in granitic formation, free from unusual difficulties, has been regarded on the job as commendable progress. In the heavy ground 240 feet per month was the customary progress, while in the shale with no unusual obstacles 600 to 750 feet per month was expected."

REMAINING WORK

For the work of taking down the top or roof, left by the under-cut heading, the Sullivan Class UD, (3-in.) drills on the River Portal and the Class UB, (2-½ in.) drills previously used on the West Portal are now being employed. Horizontal holes are drilled by machines mounted on bars and operated from scaffolds,

near the top of the finished tunnel, so that, when shot, the alignment of the roof and walls will be maintained. In taking down top by this method, some rock comes down in pieces too large to be easily and economically handled and it is necessary to break these into smaller pieces. For this purpose Sullivan Class DH-15 Hammer Drills are used, putting in shallow holes for pop-shots. The use of this drill, which is primarily designed for quarry work, is comparatively new in Western tunnels, and its success for this purpose will be noted with interest by those connected with tunnel work.

When the tunnel was started in 1905 it was hoped that it would be completed so that Gunnison River water could be turned on to the 130,000 acres of land to be irrigated in the Uncompahgre Valley in the summer of 1909. Many unexpected and unavoidable delays have occurred so that under present circumstances it will be the spring of 1910 before the objects to be obtained from the tunnel can be realized.

The official opening of the tunnel took place September 22d to 24th, on the occasion of President Taft's visit to Colorado. Active use, however, will not begin until some time later.

The completion of the tunnel will mean the increase in value of many acres of land from practically nothing to hundreds of dollars an acre, and it is not beyond the bounds of possibility to suppose that the marketing of the yield from all these acres, added to the present yield of the neighboring country, will so tax the railroads now operating through difficult mountain passes that the driving of another, possibly greater, tunnel for transportation purposes will be required.

The details of construction and methods employed in this enterprise were described by Mr. M. G. Dull in an article published in "Mine and Quarry" for August, 1908. A very complete article, from which the writer has taken the liberty of quoting, also appeared in the "Engineering Record" for August 28, 1909. This was written by Mr. J. W. McConnell, the first Project Engineer in charge of the work.

Hoisting Mine at River Portal

Sullivan Mine Fan and Surface Plant of the Clinton Coal Co., Clinton, Indiana.

VENTILATION AT AN INDIANA COLLIERY

WRITTEN FOR "MINE AND QUARRY" BY M. C. MITCHELL*

The bituminous coal mines of the present day offer ventilation problems which vary greatly from those of a few years ago, owing to the greater extent of mine workings and the changes in method required with increasing tonnage. In former years, when the mines were shallow, the workings limited in area, and the miners few, ventilation was a small consideration. Some mines depended on natural ventilation; others employed small furnaces to create an air current, and later on, as mining progressed, slow-speed fans came into use.

Slow-speed fans were suitable for mines in which it was possible to drive large air-ways, permitting the use of low pressures. In the mines of today, however, slow-speed fans are being replaced by ventilators of high speed and efficiency, better capable of forcing large volumes of air against the high resistance occasioned by long air passages.

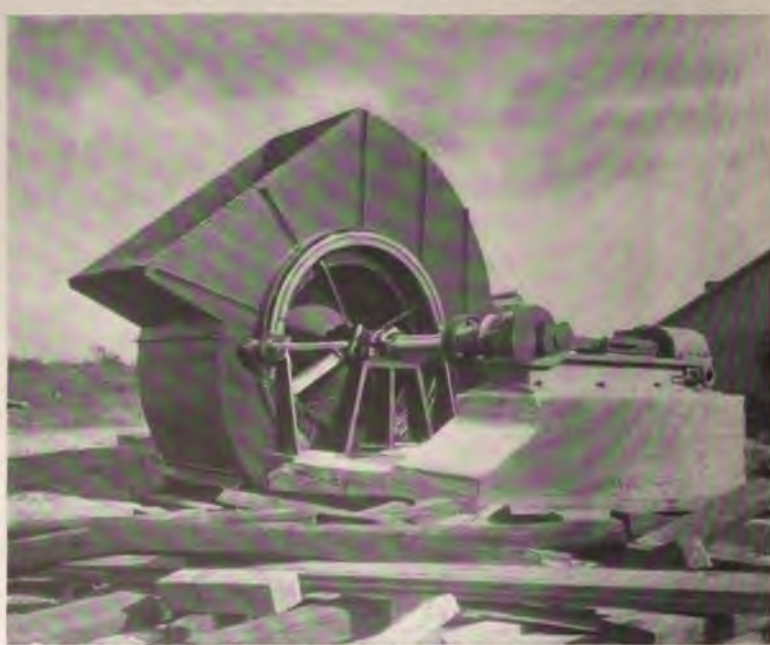
MINES OF THE CLINTON COAL CO.

This change in ventilating practice is well exemplified in the Crown Hill Mines of the Clinton Coal Company, at Clinton, Indiana. About eight years ago, the company sunk its No. 1 shaft to what is geologically termed the No. 7 seam, 164 feet from the surface, and five feet thick. They installed at this mine a slow-speed fan, 18 feet in diameter. This gave ample ventilation until about two years ago. By that time the mine was producing about 1,000 tons per day, and the number and length of the air-ways taxed the fan to its full capacity.

At about this time the company put down a shaft to the No. 6 seam, about 340 feet from the surface. This seam is six feet thick. The new shaft, known

* Missouri Trust Building, St. Louis, Mo.

Sullivan Mine Fan in Process of Installation for Crown Hill Mines, Clinton, Indiana.



Fan Complete, with Engine and Hood. The Pinion Shaft for reversing the Hood appears at the left. Hand wheel not yet placed.

Rear of Fan House, showing the Fan blowing air into the mine.

The Fan Running as an Exhauster.

instantly, without stopping the fan. The photograph at the top of page 322, shows the fan shaft and the lower half of the supporting rings or runways in place. On page 323, the upper view shows the fan blowing air into the mine, while in the lower photograph the hood has been rotated, and the fan is drawing air out of the shaft. The lateral wings or plates noticed about the mouth of the hood provide the necessary packing to prevent leakage. Two doors are used, merely to protect the fan in case of an explosion. The foundations are small, as will be seen by reference to the photographs. This installation required about 27 cubic yards of concrete, for the foundations, and about 19,000 bricks for both the engine house and fan house.

PRESENT VENTILATION

The cuts on page 322, show the house covering the old 18-foot fan, which, with the 10-foot fan first placed at the No. 3 shaft, has been shut down ever since the Sullivan fan was set to work. The 18-foot fan was unable, as above noted, to air mine No. 1 properly, while that at mine No. 3 was sufficient for a production of only 200 tons per day. At present the new fan supplies ventilation for 290 men and 17 mules in Mine No. 1, producing 1,200 tons daily, and for 146 men and 9 mules in Mine No. 3, whose present output is 750 tons per day. The air in this mine has a travel of about two miles and has two splits. In No. 1 there are three splits, and about seven miles of air-ways.

The state law of Indiana requires 100 cubic feet of air per man, and 300 cubic feet per minute for each mule. This is more than cared for by the fan at a speed of 130 revolutions per minute. The fan has been thoroughly tested to learn its efficiency, up to 245 r. p. m. At this speed it moved 154,000 cubic feet of air per minute, against a four-inch water-gauge. It is estimated that the ultimate pressure required in ventilating these mines will never exceed a three-inch water-gauge.

GENERAL MINING FEATURES

The Clinton Coal Company's mines are well equipped in other respects, both on the surface and below ground. Page 321 shows the steel tipple at No. 3 mine and the wooden structure over the old No. 1 shaft.

Electric locomotives were installed about two years ago in No. 1 mine, to gather the cars in trips at the various partings, and haul them to the foot of the shaft. All coal here is mined by hand, but in No. 3, the coal is undercut by 22 Sullivan compressed air pick machines, of the Class 5 pattern, weighing 825 pounds, and cutting to a depth of 5½ feet.

The writer acknowledges the courtesy of Messrs. H. M. Ferguson, General Manager of the Clinton Coal Company, Mr. A. P. Gilmore, Superintendent, and of Messrs D. R. Griffiths and L. Kelley, managers of Nos. 1 and 3 mines, for assistance in preparing this article.

Sullivan Duplex Channeler, Class "FW," in the Friendsville Quarry

QUARRYING MARBLE IN TENNESSEE

IMPROVED METHODS AND MACHINERY

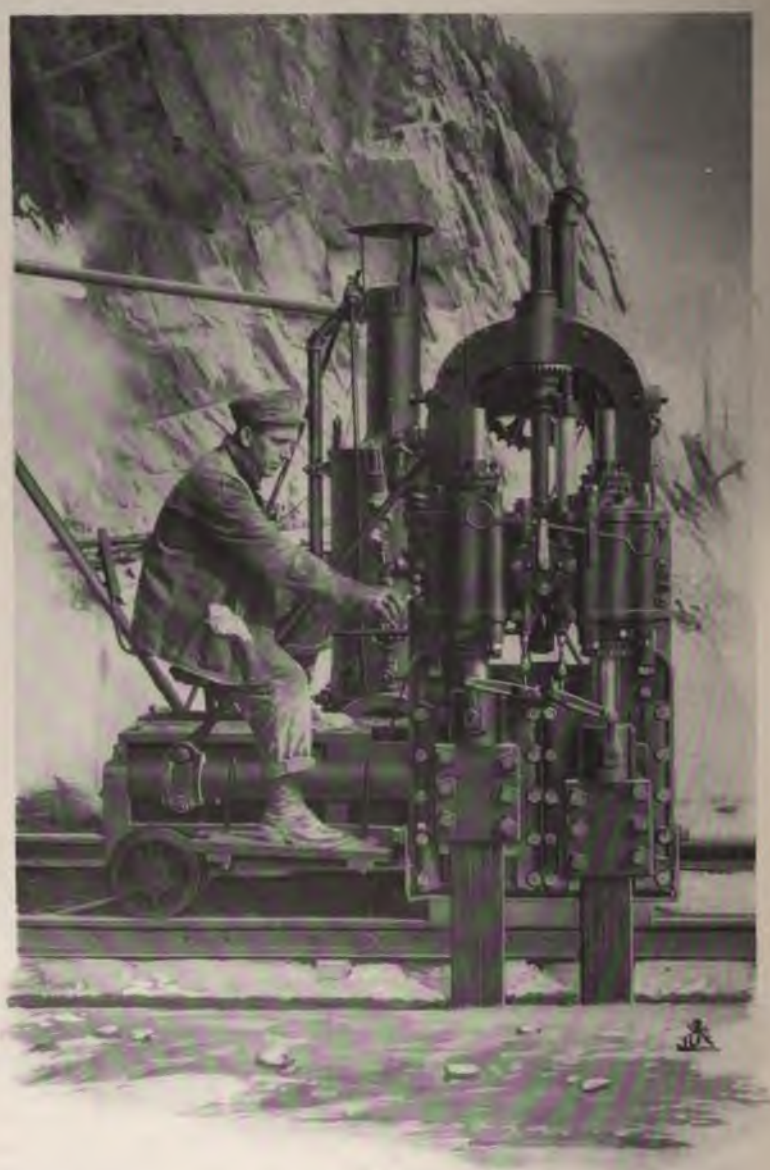
Written for MINE AND QUARRY by R. C. HARRISS.*

he Tennessee Marble deposits, situ- in Knox, Union, and Blount Coun- within a radius of 20 or 30 miles of ville, differ in numerous respects those in other parts of the country. ead of lying in regular, uniform beds, those in Georgia and Vermont, the ssive strata are uneven, particu- at the surface. This is due to geo- al disturbance, followed by the ac- of water and the abrasion of glaciers. he marble crops out in piles of large lders, separated by wide cracks or seams. Frequently, as in the case he quarry to be described below, the seams gradually close below the surface, approaching a solid formation. This circumstance makes quarrying more costly and uncertain than if the deposits were solid and uniform.

The photograph on page 326, shows a general view of the quarry of the Evans Marble Company, at Friendsville, Tenn., in Blount County, some 20 miles south of Knoxville on the Louisville and Nashville Railroad. The value of the marble secured here more than offsets the difficulties attending its production. The stone is of very fine grain, compact and hard. It is practically a pure carbonate

*Knoxville, Tenn.

Quarry of the Evans Marble Company, Friendsville, Tenn. Sullivan Duplex Channelers at right and left.



Sullivan ''Class VW'' Duplex Channeler at Work in a Vermont Quarry.

One of fourteen Sullivan "Class 4-3" Double Head Channelers in the quarries of the Georgia Marble Company, Tate, Georgia.

...arry makes short lengths of track ...ary.

...mally both gangs are run at the ...me, but at any time desired the ... may stop either engine and con... the other alone. This is all eas... fully handled from the runner's ... moving a single handle.

...h cylinder also has its own cushion ... allowing either or both to be ...ed, as desired. This feature is of ... when starting down a cut and in ...g through a mud seam, to protect ...ut heads from damage. By means ...off valves, the force of the blow ...ed by the stepping engines may ...ulated to best suit the conditions ...work being done.

...W duplex machine has been found ...e easy to control, under all condi... as the single head channeler, and ...to the convenience and simplicity of ...trolling devices, and the other fea...mentioned above, it is very much fa... ...y the channeler runners and helpers.

The duplex channeler is fitted with a feeding mechanism, by means of which the cutting heads are fed downward by power as the cut deepens, and raised by power to the top of the feed screw at the end of a run. This is accomplished by a sprocket chain drive, operated by a friction clutch on the shaft of the feed engine.

TRACK-SHIFTING

The duplex channeler is, of course, heavier than the single machine. This is not a serious inconvenience, however, as it is moved from place to place in the quarry by means of an improved method of track-shifting. This is indicated in the illustration on page 330. When moving, two screw jacks permanently attached to the rear of the frame are used to raise the machine on that side off the rails. The cutting gangs are then fed down until the wheels on the front side are off the track, thus supporting the channeler on the jacks and steels. It is then easy for two men to shift

A Duplex Channeler Raised from the Rails to Permit Track-shifting.

the track forward to the new position, and the machine is then lowered back onto the rails.

CUTTING CAPACITY

With its class 6½ channelers, the Evans Marble Company averaged 80 square feet of channel per day of ten hours. Under the same conditions the VW channeler cuts on the average 200 feet, while runs of 350 feet have been recorded on various occasions.

It will be noted from these figures that the VW duplex channeler has a capacity more than twice as great as the single head machine, even on runs of no greater length than 20 feet. The increase in efficiency of the VW over two single head channelers would be greater on cuts of greater length.

This excess in capacity, over the work of two single machines is explained by the fact that with the VW two sets of steels are used in doing the same amount of cutting as one set in the single cylinder machine, which means that the steels in the VW machine retain their cutting edge better in running down a length of steel. The mud or sludge is also less of a hindrance, by reason of the greater frequency and alternation of the blows. The other advantages of the VW machine, as above outlined, also contribute to a great extent in the increased cutting capacity.

The home office of the Evans Marble Company is located at Baltimore, Md., with large cutting mills at Baltimore and Knoxville, Tenn. They operate several quarries in the Knoxville marble district.

The writer is indebted to Mr. E. N. Willard, manager, and Mr. R. F. Young, Superintendent for information and aid in preparing this article.

Diamond Drill Scow. Power House and Wreck of Dam., Hauser Lake

TEST BORINGS FOR DAMS AND BRIDGES

ighway bridge at Peoria, Illinois, the Illinois river recently collapsed. ailure was due to the scour of the around and under the pile footings piers. These piles were supposed o been sunk to solid rock. In fact, gs, made for the purpose, had in- d rock bottoms.

borings were made with a churn and the engineers' opinion that bed had been reached, was based on the and cuttings, washed up in the ary way. Aside from the unwisdom ving piles through rock strata and es this instance is one of many which demonstrated that wash borings e be relied on to show the location ature of mineral formations. In the er, 1908 issue of this paper, Mr. F. H. ridge, resident engineer of the Chi- and Northwestern Railway at Clin- ton, described the methods used to bed rock for the foundations of a ridge across the Mississippi. The ompanying diagram is reproduced from article. In it the dotted line shows of rock as indicated by wash borings churn drill, while the full line shows the true ledge located by diamond drill cores.

Experience has shown that a core of all materials penetrated is the only sure evidence that rock encountered is not a boulder or an overhanging shelf.

The city of Austin, Texas, had an experience of this sort a few years ago. A water supply dam on the Colorado river gave way, a large section of it being carried bodily down stream. Subsequent diamond drill work showed that the dam had been built immediately over a geologic joint or fault and on permeable rock strata which allowed the water to undermine the foundations.

In the spring of 1908, an unusually heavy freshet on the upper Missouri river washed out the Hauser Lake Dam of the United Missouri River Power Co. Diamond drill borings again demonstrated that the dam had been built in an unsafe place, and a new site is now being selected. Near Wolf Creek, some 20 miles further down the river, other boring has been done for a second plant.

The Austin and Missouri river drilling work was accomplished very largely from

scows in the rivers, and was executed under contract for the engineers by the Sullivan Machinery Co. A brief description of the methods used may be of interest to those contemplating similar work.

AUSTIN DRILLING

The test work at Austin, Texas, was done for the Austin Water, Light and Power Commission in the summer of 1908, under the direction of Walter G. Kirkpatrick, M. Am. Soc. C. E., of Jackson, Miss.

The river at this point, some two miles above the city, is about 300 feet wide, and runs between limestone banks, from 40 to 75 feet high. The old dam was 1,091 feet long and 60 feet high, and was washed out in 1900.

The drill used was a Sullivan "Class HN," capacity 500 feet, removing a two-inch core. Between 25 and 30 holes were bored at intervals of 20 feet in two lines, 20 feet apart. The borings were continued on both banks, and at least one hole, 150 to 200 feet deep, was sunk on each side, to determine the extent of the formation.

The holes bored from the surface of the river ran from 30 to 50 feet in depth. While the work was in progress, the water ranged from three feet six inches deep near the banks to fifteen feet, the average depth being about ten feet.

The manner of handling the drilling outfit was somewhat different from that employed by Mr. Bainbridge on his Mississippi river work. The drilling scow was 20 feet long by 12 feet wide, with a draught of about two feet.

The diamond drill was mounted on one side of the scow, on an overhanging platform, with an improvised tripod for hoisting the pipe and drill rods. The boiler occupied one end of the scow, and the pump and other equipment the other. When the scow reached the proper location pipe spuds set at each corner were lowered to the river bottom and the boat jacked up a few inches on these supports. This process took the weight of the scow off the running water and threw it upon the pipes, so that the drill rested on a firm foundation.

When the operation was reversed the hull was allowed to settle into the water, the pipes raised from the bottom, and the

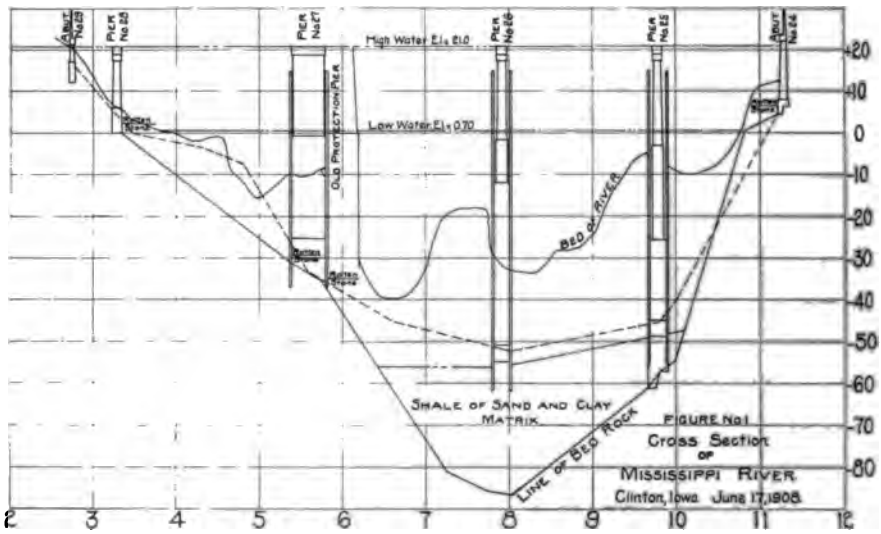


FIGURE No 1
Cross Section of Mississippi River
Clinton, Iowa. June 17, 1908.

snow towed to the site of the next hole. In only one instance was it necessary to leave a hole before completion. In this case, the water rose two feet in less than an hour, requiring the drill men to uncouple the machine and tow the boat up against the face of the old dam for safety. The standpipe was left in the hole and drilling was resumed later without losing the work already done.

The results of the drilling showed a hard, solid bed of limestone at a depth of 30 to 40 feet below low water level. Above that point were found alternating hard and very soft chalky layers, interspersed with cavities, and overlain with a deposit of boulders, broken rock, gravel, clay and sand. It is believed that the old dam was weakened by leakage of water through these layers, and through the fault referred to, so that when the high water came, the dam and the rock just below it slid and settled at the same time.

HADDEN LAKE DRILLING

The photographs with which this article is illustrated, show the diamond drill outfits, and phases of the drilling work, on the site of the old Hauser Lake Dam which was wrecked April 30, 1908. The Stone and Webster Engineering Corporation are consulting and contracting engineers, in charge of reconstruction for the United Missouri River Power Co.

Drilling was begun about August 15, 1908, and has continued intermittently until the present. The conditions here were more difficult for drilling owing to the greater depth of the water and the swiftness of the current.

The snow used at Hauser Lake last fall, and a similar one recently at Wolf Creek were 40x24 feet by four deep. The photograph on page 334, shows the snow and drill at Wolf Creek. That on page 334, gives a better idea of the methods employed. The first step, after arrival at the site of a hole, was to sink stand pipe to solid rock, using a class "N" drill for the purpose, as shown below. Six inch casing was driven through the overburden to the rock. This pipe was guyed securely by anchors and cables.

Sinking 6-inch pipe, Hauser Lake Site

Sullivan "Badger" Drill; a detail of the drill and platform

Sullivan "Badger" Diamond Drill on six-inch Standpipe. "N" Drill Engine and Drum at right. Wreck of Dam in background.

The Badger drill was then mounted over the 6 inch pipe on a platform clamped to it as shown on page 333. Size "A" bits, rods, etc., are used for the actual core drilling, removing a 1⅝ inch core. The hoisting of rods was done with the "N" engines as shown on this page.

The six-inch pipe affords a steady foundation for the drill, so that the latter is not affected by changes in water level or by the current. The water averaged 35 feet deep at the Hauser Lake site, so that jacking up the scow on spuds or pipes, resting on the river bottom was out of the question.

About 25 holes were bored at the Hauser Lake site. They were sunk 16 feet into bed rock, and established the presence of a flinty ledge, without deep holes or depressions, about 55 feet below mean water level.

The Sullivan Machinery Co. has also under contract a large amount of drilling for the Canadian government on the site of the Quebec bridge across the St. Lawrence river. The same methods are employed there as in Montana. This bridge is to replace the one which failed during construction in September 1907, due to faulty design of the superstructure. The Canadian engineers are determined to take all possible precautions against failure in this fresh undertaking; hence the diamond drill borings.

Diamond Drill outfit at Wolf Creek Site.

Sullivan Automatic Slide Valve Hoist, side view.

A NEW HOISTING ENGINE

The Cleveland Cliffs Iron Company has recently installed a hoisting engine at its Lake Shaft, near Ishpeming, Michigan, which comprises some unusual features.

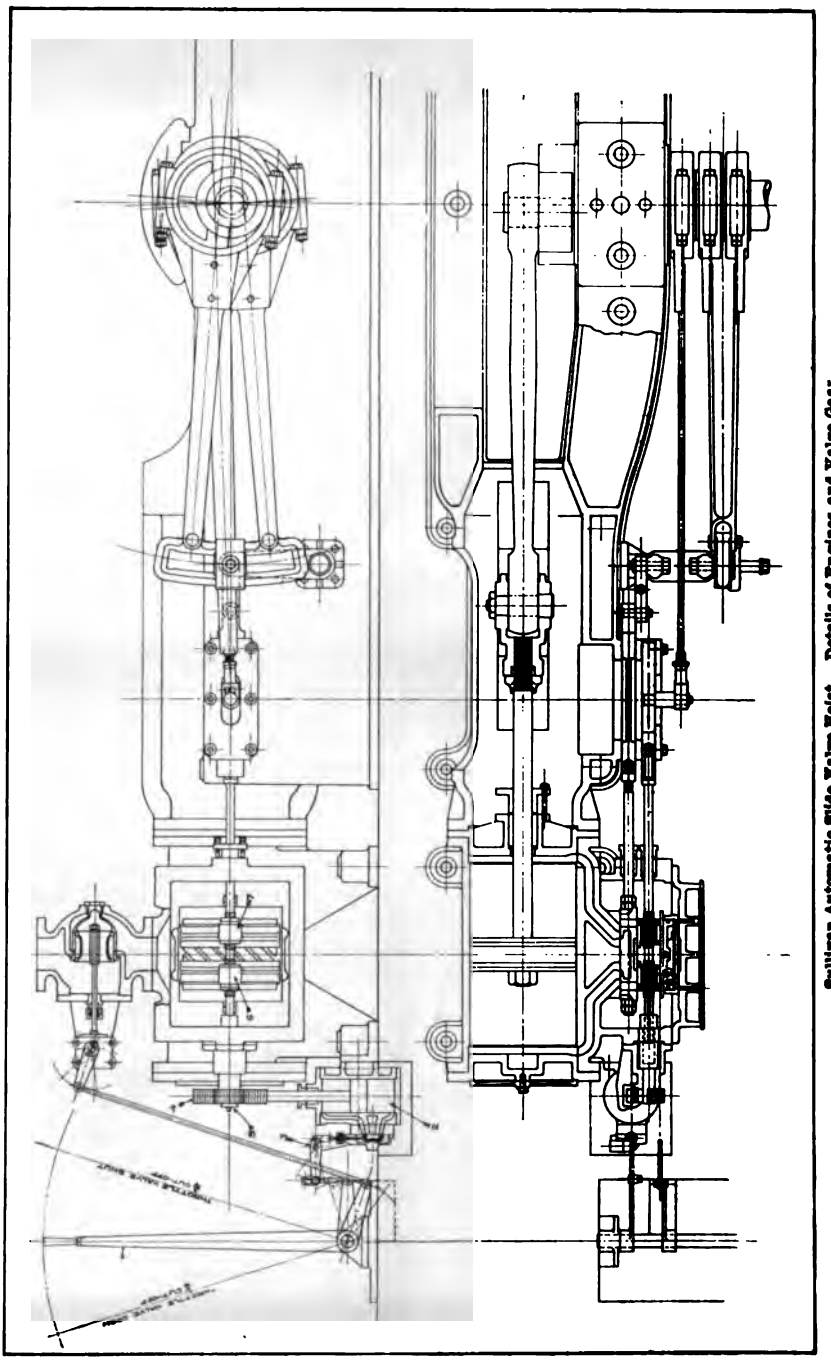
This plant consists of a drum, six feet in diameter, by six feet face, keyed to the shaft and driven through a gear and pinion by two 14x18-inch slide-valve reversing engines. The drum carries two 1⅛-inch steel ropes, 850 feet long, and hoists in balance from two compartments of the shaft. It is capable of a net load of nearly six tons, which may be hoisted at from 720 to 860 feet per minute, depending on the engine speed, which varies from 150 to 180 revolutions per minute. Steam is furnished at 150 pounds pressure.

This hoist differs from other second motion slide valve plants in its steam economy, which is equivalent to that of a Corliss hoisting engine designed for the same service. This unusual efficiency is gained by automatic regulation of the point of cut-off of the slide-valves.

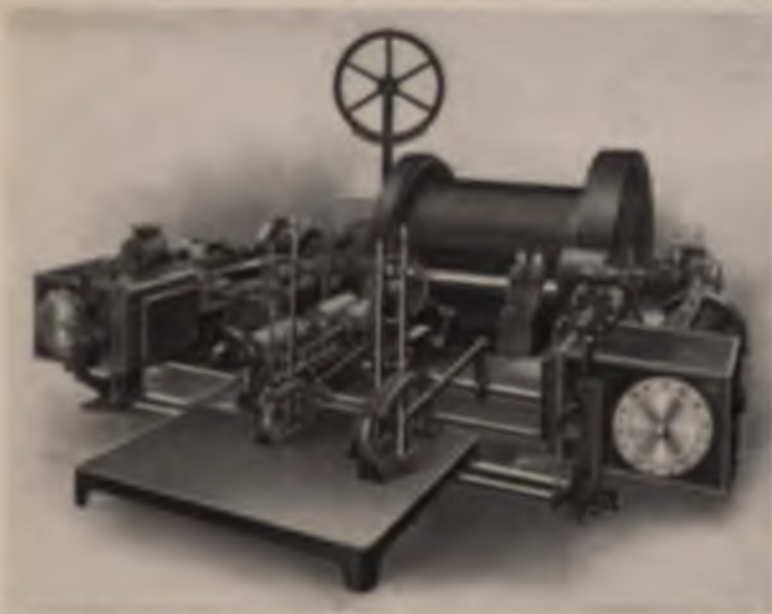
It may be asked: "Why is not the Reynr cut-off, with hand wheel adjustment, suitable for hoisting engines?" To adjust the cut-off by hand in this instance is out of the question, since it is necessary for the engines to take steam the full length of the stroke in starting the load; when the load is fully under way, the cut-off must be set in its shortest position. The cut-off must be lengthened again at the end of the hoist for the next load, and this operation repeated each trip. It is evident that no engineer has time to operate the screws between trips, nor would it be possible for him to set the cut-off at its most economical point each time, owing to variations in steam pressure and load.

The objection to using Corliss engines on geared plants, and thus gaining the desired economy, is that the Corliss valve gear and cut-off cannot be operated above a certain speed, so that the cylinders must be built with such a long stroke as to render the plant unduly expensive.

The device employed for doing this work automatically in these slide valve plants does not in any way limit the



Sullivan Automatic Slide Valve Hoist. Details of Engines and Valve Gear.



Sullivan Automatic Slide Valve Hoist built for the Cleveland Cliffs Iron Co. Rear view showing hoisting motion.

speed at which the engines may be run, thus permitting an engine of the most economical size and speed to be selected for a given duty. At the same time, it is possible to control the steam distribution as closely as in a Corliss engine, instead of wasting fuel by carrying steam the whole length of the stroke, as heretofore customary in engines of this pattern.

This invention, therefore, renders available a type of hoisting engine long sought by mine operators, one having moderate capacity and speed, with high steam efficiency, all obtainable at a price within ordinary means.

Credit for the new departure is due the engineers of the Sullivan Machinery Company, who have made a specialty of hoisting engine design for many years. An entirely new method is employed for controlling the cut-off of the slide valves. A double valve is used, as in the case of engines in which the steam distribution is controlled by hand adjustment. When starting the load, steam is admitted to the cylinders for the entire stroke. When the acceleration period is completed, the cut-off is automatically set at its shortest position in the following manner (see the drawing on page 336):

When the throttle-valve hand lever, No. 1, is thrown, the main throttles are opened by the first two or three inches of the movement, admitting steam for the entire stroke to start the load. As the lever is pulled back, it permits steam to enter cylinder No. 2, through the valve mechanism marked No. 3. The piston-rod of this cylinder ends in a vertical rack, No. 4, which engages a horizontal pinion, No. 5, located at the outer end of the spindle of the Meyer valve gear.

When the steam enters cylinder No. 2, by the movement of the throttle lever, the action of the rack and pinion automatically places the steam valves in the position of shortest cut-off. At the end of the trip the reversal of the lever, to

close the main throttles, admits steam to the opposite side of the piston in cylinder No. 2, and the cut-off is restored to its first position, to start the load from the bottom.

It will be noted that the automatic cut-off engine shown in the photographs is in a horizontal position. This enables the cut-off of both cylinders to be handled by one cylinder. The racks, in this instance, are operated by bell cranks.

It will be seen from the above description that the apparatus employed is very simple, and its action positive, reliable and not subject to derangement. It is entirely automatic, requiring no effort of action or attention on the part of the engineer, after the eccentrics have been set, to secure the most economical operation possible with the service factors of load and steam pressure which are prevalent. The slide valves are operated by separate eccentrics, with the usual link motion, the third eccentric shown on page 336, being for the cut-off. The range of the cut-off is from three-quarters to one-quarter at the latest setting, and from four-tenths to one-tenth at the earliest.

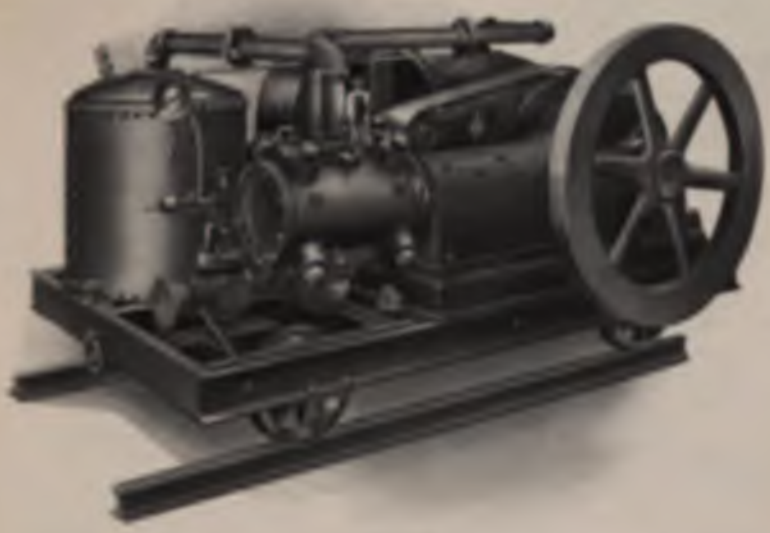
GENERAL FEATURES

The photographs on pages 335 and 337 show the general appearance of this hoisting plant, and of others of the same type. The drum is fitted with a heavy band brake, steam operated, with a wheel for setting the brake by hand at any point, for inspection or repairs, when the plant is not under steam. The gear and pinion are made of cast steel with cut teeth, the teeth being of such a shape that several of them are in mesh at once, thus rendering the action of the hoist smooth and quiet, even while lowering unbalanced.

The engines are mounted on heavy duty frames, the pillow block section and guide section being cast in one piece. The bottom, of these frames form enclosed boxes, to prevent oil from touching the foundations.

The hoists of this pattern are built in in several stock sizes, and all parts are interchangeable, enabling them to be made and sold at a smaller cost than is possible when each plant is a special proposition. It is expected that they will be employed extensively in mines where the requirements of depth, speed and load do not warrant the purchase of a first motion Corliss plant, but where economy of fuel is a factor.

The Cleveland Cliffs Iron Company has three other Sullivan Hoisting plants at its mines. One, at the Cliffs Shaft, consists of two 10-foot clutch-driven drums, operated by gearing from a 24x48 inch Corliss engine, with fly wheel brake. At the Stevenson Mine is a first motion plant, with a cross compound Corliss engine and two 12-foot drums, while the principal hoist at the Lake shaft, which the automatic slide valve machine above described serves as an auxiliary, consists of two 20x42 inch Corliss engines, driving directly two seven-foot clutch-operated drums.



Sullivan Motor-driven Compressor outfit on a mine truck

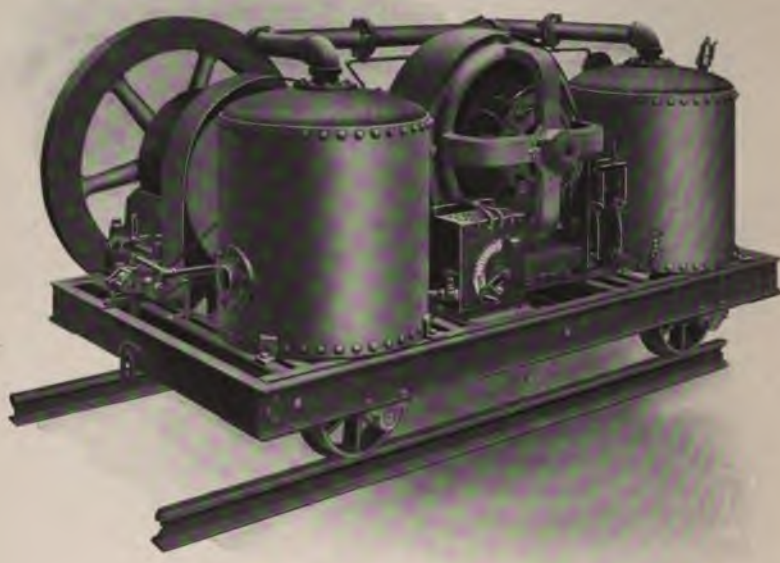
A PORTABLE ELECTRIC AIR COMPRESSOR

In mining and industrial service, there are many occasions when electric power is abundant, but in which work arises, which can be done to better advantage with compressed air. Again, when air power is on hand, it is sometimes inconvenient or impracticable to carry pipe lines to the work, whereas electric wires can readily be brought up to the working face or point of application. Among such instances are the operation of coal-pick machines in driving headings, the use of hammer drills or rock drills in remote and inaccessible workings, or any sort of temporary or occasional work in mines or construction undertakings, equipped with electric, but not compressed-air energy.

Another instance is that of pneumatic tools, — for example, in bridge or other steel construction, — where it is desired to convert electric into air power as cheaply as possible.

An air compressor for special service of the kind described, has recently been designed by the Sullivan Machinery Company, and is now in successful use. It is known as the class "WK" machine, and in the form shown in the accompanying cuts, is intended primarily for mining work. This outfit consists of a standard single stage compressor, driven by a silent chain from an electric motor, both motor and compressor being mounted on a truck, with wheels to fit the gauge of the mine track. The compressor is an adaptation of the Sullivan Class "WG-2" belt driven machine, the only alteration being the substitution of a sprocket or gear wheel for the chain drive, at one end of the crank shaft, in place of the two pulleys used with operation by belt. The crank-shaft, connection-rod, and other main working parts are contained in an iron housing, and are self-lubricated by the splash method.

The air cylinder is fitted with automatic poppet inlet and discharge valves, which are easily removable for inspection or cleaning. The air cylinder and heads are water-jacketed, the cooling water being



Sullivan class WK Compressor outfit, rear view, showing motor, receivers and circulation pump.

supplied by a pump, mounted on the truck, and taking its power by chain and sprocket from the compressor crank-shaft. This pump draws its water-supply from any convenient source, usually tanks or barrels on a standard mine car. The air inlet opening is covered with a screen to keep foreign substances from entering the air cylinder, and an unloading device is attached to this opening, arranged so as to shut off the supply of air, thus cutting down the amount of power used, whenever the air pressure in the receivers reaches the desired limit.

The motor is of the shunt wound continuous current pattern, and may be arranged for any desired voltage. It is fitted with a main line switch and fuse connection, mounted on a slate base, and a starting rheostat, with the necessary wiring and connections between the two.

One compressor of this type, which has been built and supplied for coal-mining service, has a 10 x 12-inch air cylinder, furnishing about 175 feet of free air per minute, at 150 R. P. M. The horse-power of the motor is 25, which easily maintains an air-pressure of 80 pounds in the receiver. This capacity is ample to operate a coal-pick machine or two small reciprocating rock drills, or several hammer drills or pneumatic tools.

The air-discharge from the compressor is delivered in series to two vertical receivers. Two receivers are employed, first, to keep down the height of the machine, and second, because a single horizontal receiver would not permit the necessary compactness of arrangement, and the proper relation between the positions of the compressor and motor.

The motor and compressor are bolted

[illegible] to a steel [illegible] which [illegible] a vertical to a structural steel frame, mounted on the tracks.

In some cases of industrial work it will [illegible] underground workings [illegible] a surface [illegible] which [illegible] with rock [illegible] may be substituted for those with flanges and the rock hauled from place to place on the floor of [illegible] the bridge [illegible] of other rail road service the tracks may be located in a manner [illegible] a [illegible]

DEEP DIAMOND DRILLING.

[illegible] the Mines [illegible] of Mines [illegible] Queens [illegible] a description of a diamond [illegible] feet [illegible] near Perth [illegible] on the ground of the Queens Development Co. At the time this hole was bored it was the deepest core [illegible] of which there was any record in the North American continent since that time the record has been [illegible] feet [illegible] by Messrs Cox & McDermid of Virginia, Minn. [illegible] and by the Diamond Drill Co. of Toronto [illegible] of the Canadian Mine east of Republic, Michigan, on the Marquette Range. The [illegible] with rock [illegible] may be substituted for those with flanges and the rock hauled from place to place on the floor of [illegible] the bridge [illegible] of other rail road service the tracks may be located in a manner [illegible] a [illegible]

BOOKS AND REPORTS

"Mine and Quarry" has received from time to time copies of the very thorough and complete reports issued by the Canadian Department of Mines. Mr. A. P. Low reports on the [illegible] and Mr. J. Obalski [illegible] on the [illegible] and by the Department of Public Works of Canada. These reports are very [illegible] and are as follows:

Report of Mines Branch for year ending December 31, 1903. 90 pp.

The Iron Ore Deposits of Nova Scotia, in two parts. Part I. 250 pp. 50 plates by J. E. Woodman, A. M. [illegible] Ph. D. [illegible] A. M. E. M. I. M. E.

The Chromite Iron Ore Deposits in the eastern townships of Quebec. 161 pp. 20 plates by Eugene Coste, M. E.

The Tungsten Ores of Canada. 36 pp. 10 plates and bibliography. By T. L. Walker, M. A. Ph. D.

Investigations of an Electric Shaft Furnace. Illustrated. Section with plates. 60 pp. By Eugene Haanel, Ph. D.

The Peat Bogs and Peat Industry of Canada. 1903. [illegible] 250 pp. with maps. By Eugene Haanel, M. D. etc.

Report on the Survey of the Proposed Georgian Bay Canal, with plans and estimates of cost. 100 pp. [illegible] illustrated with views of the proposed route and 10 plates in the form of diagrams. By H. Lefroy, A. M. Inspector. By Lieut. Col. John J. Stevens.

There are [illegible] the extended [illegible] which these reports deserve. They may be obtained from the Department of Mines, Ottawa.

A New Sullivan Stoping Drill

Greater Drilling Speed
Lower Cost of Operation

Bulletin 160D

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MINE AND QUARRY

DIAMOND DRILL IN USE AT LAWRENCE, NEW YORK

AN ILLINOIS COAL MINE

BARRE GRANITE

THE VERMONT CUTTER COMPANY

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MANE AND QUARRY

View of first Quebec Bridge, taken shortly before the collapse

DIAMOND DRILLING IN THE ST. LAWRENCE RIVER, ON THE SITE OF THE QUEBEC BRIDGE

WRITTEN FOR "MINE AND QUARRY" BY J. A. WENTZ

Many readers will recall the failure of the Quebec bridge, across the St. Lawrence River, which occurred on the 29th of August, 1907. This bridge was of the cantilever type, with two shore piers and a river span 1800 feet long, 150 feet above the high water level of the river, which is 180 feet deep at this point. The bridge was being constructed for the Canadian Government, at a point about eight miles above the city. It was designed to carry two railroad tracks, two street railway tracks, two roadways, and two footways. It was to have been 67 feet wide and 400 feet in height to the peak of the main piers. When the river span, intended to be 900 feet from the center of the river to the north pier, had been constructed to a point 740 feet from the pier, some defect caused the collapse of the whole mass, carrying with it eighty men, of whom only four were rescued. The photograph on this page shows the bridge as constructed to the farthest point attained.

Work on the bridge was begun in 1902, so that five years' work was lost by this accident. Fresh plans have now been prepared by a Board of Engineers consisting of Messrs. Ralph Mojeski of Chicago, H. E. Vautelet of Montreal and Morris Fitzmaurice of London. The new bridge will cross the river at the same point as the old.

When the sites for the main piers were originally selected, the engineers were satisfied with the tests then made of the bottom. But there has been a marked advance in standards of accuracy in such matters in the last five years, and it was therefore decided to test the river bed and shore thoroughly with core drills to make sure that the piers were on a solid footing.

The Sullivan Machinery Company of Chicago was awarded the contract for this work, with diamond drills, and employed two crews from May until November of this year. In all, nineteen holes were sunk,

and 2,000 feet of drilling performed. Some of the holes were on land, some at the shore line, in shallow water, and others on the river itself. The land borings were made in the usual manner, from the ground surface. For the shore borings, platforms 20 feet high were built, so that the drill was out of water at the highest tide levels. The river work proper was done from a scow.

This work presented features of unusual difficulty; first, on account of the rapid current; second, the depth of the water, which ranged from 30 to 48 feet; third, the danger of rough weather, and fourth, the tides, which cause a daily variation of from 12 to 18 feet in the height of the water level. In addition, the ground drilled was exceedingly troublesome, consisting of an irregular deposit of sand, gravel and boulders above the ledge or bed rock, and on the borders of the river, where the shore borings were made.

RIVER BORINGS

For the deep water holes, a Sullivan "B" drill engine and hoisting drum were mounted on a scow with boiler and tripod, as shown on the front cover. The boat was held in place by from four to six 500-pound anchors. The three-quarter-inch wire cables were taken up or paid out to keep the scow steady as the tide level changed. With the "B" engine and drum, six-inch standpipe was then driven down through the drift deposit of the river bottom by means of a drive block, or weight, sliding up and down on a drill rod, thus keeping it in line with the drive shoe on the end of the pipe. The six-inch pipe was followed by 4½ inch, and this by 2½ inch casing to the bed rock, which ranged from 50 to 130 feet below the bottom of the river.

A large amount of blasting was required to sink the pipe to the bed rock through the boulders. This work was done in the usual manner, by lowering dynamite down the standpipe and withdrawing the pipe a few feet before the charge was fired.

While the standpipe was being driven, the variation in water level, due to tides, was taken care of by adding or removing the necessary lengths of pipe at the top of the line. After the drill had been set to bore into the ledge the length of the pipe remained fixed until the work was over, so that at low tide the drill was from 18 to 20 feet above water, as shown on page 344.

The actual drilling in rock was performed with a Sullivan "Badger" drill, mounted on a small platform on top of the standpipe, as shown in views on this page and the cover, and removed a 1¼-inch core. The Government specifications required that the drill should penetrate the rock to a depth of fifteen feet, to make

At Work on the Drill Platform

Drilling alongside pier of old bridge. This gives some idea of the wreckage; low tide

sure that the ledge and not a boulder had been reached. It was unnecessary to support the line of pipe through which the drilling was done by stays or guy rods, as the weight of the pipe itself and the firmness with which it was driven into the river bottom gave it sufficient rigidity.

INCIDENTS CONNECTED WITH THE WORK

The difficulties connected with this work were many, and rather out of the ordinary for a diamond-drilling scow. The water was very rough a large part of the time, owing to high winds. On one occasion all of the anchor lines parted, in spite of the fact that the time of two men was entirely given up to handling these lines. The scow went adrift, and for a time it seemed as though the whole outfit would go to the bottom. The crew were not used to sea voyages, and *mal de mer* added to their difficulties. By quick action on the part of J. V. Harrison, the superintendent, a tug was pressed into service, and the scow overtaken and towed to safety. The swell from ocean steamers bound to and from Montreal caused loss of time and annoyance, until an order was obtained from the Government officials requiring vessels to slow down while passing the scow.

Drilling alongside the pier; high tide

Sullivan ''CE'' Mining Machine crossing the face of a room

Sullivan Mining Machine driving an entry

Electric Locomotives in the main bottom entry

The Electric Power Plant

Surface Plant of Big Muddy Coal and Iron Company, No. 9 Mine

Coal for the boilers is carried from the tipple to the boiler house by a chain conveyor, capable of handling 50 tons per hour.

Loading out coal from an undercut room

...ette Coal Co. of New York ...a briquetting plant for making ...al into briquettes. This plant ...ast north of the boiler house, ... in operation shortly.

...er is indebted to Mr. Hirum ...perintendent of the Company ...ines, for the above data, and ... Mitchell, Mine Manager, and Frank McFarlin, Master Mechanic, for assistance in securing the photographs used in this article. The general offices of the company are in the Wainwright Building at St. Louis, whereas all business is carried on for the mines in Jackson and Williamson counties. Mr. O. L. Garrison is the president of the Company.

Class "E" Sullivan Diamond Drill, Vermont Copper Company

THE VERMONT COPPER COMPANY[1]

A NEW ENGLAND "ANTIGUA"

The property of the Vermont Copper Company, in Orange County, Vermont, belongs to the older generation of mines in the United States. As the Vermont Copperas Company, it was a producer of copperas, as early as 1790. It was not until about 1837 that the ore began to be treated for the copper it contains (about 2.5 per cent). Until the development of the Lake Superior district, the mines of this county were the largest shippers of copper in the country. The output of the mine was hauled to Boston by wagon. Surveys for a railroad have since been made in all feasible directions, and the state has issued a charter for such a road, but it has not yet been built. Transportation is still by wagon, to the Boston and Maine station of Pompanoosuc, 12 miles northwest. The village of South Strafford, two miles to the west, is the nearest town.

ORE

The ore occurs in lenses in what appears to be a fissure vein. It consists largely of pyrrhotite in which is a small amount of chalcopyrite, finely disseminated through the ore body, so that in previous concentration methods a large percentage was lost. The wall rock, both hanging and foot, is a micaceous schist. The strike of the vein is approximately north, 20 degrees east with a dip varying from 70 to 50 degrees as depth is gained.

DEVELOPMENT

The ore body is 10 to 25 feet thick and the management estimates that about 400,000 tons of ore are now developed. The old work consisted of a large open pit, in which hand labor was employed. The great extent of the surface croppings finally led to underground exploration and development, and to machinery. The mine extends several thousand feet in a north and south direction. A haulage tunnel, 1,500 feet long, runs into the mountain from the power house, and taps the vein at a depth of about 400 feet. The vein has been opened up by a drift some 1,800 feet in length, and above this level a large amount of ore has been removed. An incline 500 feet long, at the north end of the mine, is in ore 200 feet below the main level.

EXPLORATION

Three Sullivan "H," hydraulic-feed, diamond drills, are kept going day and night for the purpose of proving up a long extension of the vein which has been followed. In order to prove thickness the holes are bored on a slant to cut across the vein. One of these drills is shown on page 351. The cuttings in the vein and the core are used for estimating the quality of the ore. These drills are all operating from the surface, and are run by compressed air. To make up transmission losses, the air is reheated by building a light wood fire for a length of five to ten feet under the inlet pipe supplying each drill. The amount of air consumed in one of these diamond drills varies, but to give an idea, it may be noted that the drop in pressure from 70 pounds, while running two of the drills together on a 1½-inch supply pipe, was 13 pounds.

A Sullivan "E" screw-feed diamond drill mounted on a frame for surface prospecting, is also in use. A gasoline engine mounted on the same frame drives the machine by belt. The water, thus far, has been supplied by a hand pump. The rods are hoisted with the engine and pulley blocks, the rope passing around the "capstan" on the fly-wheel of this machine, with about one and a half turns. The photograph on page 353 shows the general arrangement. All these pros-

[1] Prepared from notes furnished by the general superintendent of the Company.

Sullivan "E" Diamond Drill, driven by a gasoline engine

putting drills use either "E" (⅞-inch) or "A" (1½-inch) bits. These machines, drilling in the schist, make about 15 feet on an average per ten-hour day; out of the rock probably ten per cent contains quartz, sometimes solid for three or four feet. The distance covered in this prospecting will approach two miles, while the depth of holes is from 300 to 650 feet. The vein is remarkably steady, but there are pinches in it, as occurs in many ore bodies. The grade of ore on the whole is low, but some of the holes, as well as stopes in the mine, run high in copper (eight per cent).

STOPING METHODS

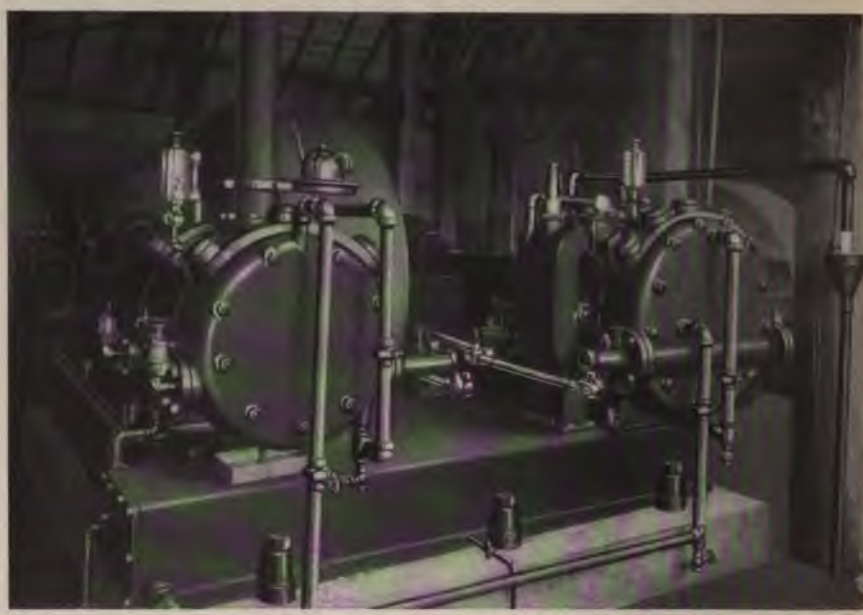
The general method of mining employed is underhand stoping. For this purpose, Sullivan "UC" 2½-inch air drills are used, mounted ordinarily on tripods, although some work is done from stoping bars. Steam drills of the same size and type have also been used for quarry or open cut work. The mining drills put in 40 feet of hole, on the average, in ten hours in this rock.

HAULAGE

The haulage roads in the mine are laid with 24-inch gauge track, and 30-pound rail. The five-ton cars are hauled by an electric trolley locomotive of 36 horse-power (seven-ton) capacity. The ore is handled in the stopes through chutes, and when necessary is hauled to the chutes in small cars. The chutes deliver to stalls above the main level, whence the cars are filled by gates at one side. The 500-foot incline is served by a small hoisting engine and automatic dumping skip. The skip dumps into a bin from which the cars are loaded.

COMPRESSED AIR

The convenience of air has led the management to use it wherever possible.



Sullivan "WJ" Belt-driven Air Compressor of the Vermont Copper Company

Power for the rock drills, winze hoist and the three "H" diamond core drills, pumps, etc., is supplied by a 14-drill Sullivan compressor, of the "WJ" duplex, two-stage, power-driven type. This machine is equipped with water-jacketed cylinders and heads, a large copper tube intercooler, semi-rotary inlet and poppet outlet valves. A cut-off regulator or unloading valve on the air intake pipe shuts off the air supply when the receiver pressure exceeds the 85-pound limit, thus enabling the compressor to run unloaded when the full amount of air is not required. This regulator and the combined bath and gravity oiling system employed for the main working parts, render the compressor practically automatic. The machine is driven by a 150 horse-power alternating current motor. For the sake of compactness, the motor is placed beside the compressor. An 18-inch belt drives a jack shaft, which transmits the power to the 30-inch main belt, running with the upper side in tension.

A 5-inch main carries the air through the 1,500-foot adit to the main level, where it branches and is reduced. The supply pipes for the diamond drills are 4,000 feet long. The entire system can be pumped up to 85 pounds pressure in four minutes, and tests have been made of the compressor by an accurate measurement of the volume shut off in these pipes and in the receiver and by checking the number of revolutions required to pump this volume to 85 pounds, due allowance being made for temperature.

POWER PLANT

Steam power was used at first, to run the compressors and blowers. A few years ago, a concrete dam 400 feet long was built on the White River, ten miles distant. The power house contains two 400 horse-power turbines, direct-connected to generators with rotating fields. The three-phase, 6,600-volt alternating current is transmitted by steel cables across the river and then by wires to the

mine, where it is stepped down to 550 volts.

The central plant at the mine includes a well-equipped machine and repair shop.

SMELTING PLANT

The ultimate object of this operation is the production of copper matte. The metallurgical process will consist in smelting in a water-jacketed furnace, allowing a deep ore column and also a heavy blast from the Root blower. This furnace is water-jacketed and about 16 feet by 44 inches between tuyères. At first this furnace was enclosed in what was supposed to be a slow-burning timber building, but last February a disastrous fire, due to a breakout of low grade matte from an enormous settler, caused the destruction of the plant. It has therefore been rebuilt out of steel and corrugated iron. The large settler has been replaced with a more reasonable one, the blower has been repaired and the furnace divided in half its original size. This is for the purpose of better control and the determining exactly of the production that can be successful on a large scale. The copper matte formerly was produced by an old jacketed furnace, but it was deemed unwise to use this with its wooden surroundings, because the height of the furnace would probably not have been suitable in all cases arising in the semi-pyritic smelting contemplated. The new furnace can at any time be rearranged so as to give the full capacity, or three-quarters capacity. Proper spouts also have been provided and it is expected that there will be no trouble from this or from lack of blower capacity.

ORE HANDLING

The ore, hauled from the mine by electric locomotive, as described above, is received in bins above the crusher in the mill, while any waste goes to a dump at the side of the mill. The ore is crushed to four inches, elevated by a belt at an angle of 130 degrees, recrushed and sampled in an automatic sampler of the Vezin type, but built according to original plans. The bins below the sampler furnish the

General view of the Vermont Copper Company's Workings. Pioneer Mine at right, mill in background

ore to a larry that travels over the bins above the furnace. These hold about 2,500 tons of ore, also coke, silica, and matte. An automatic weighing charge car run by trolley, with four beams to weigh different ingredients, then carries the ore into the furnace, from which the slag is discharged by three-tons lag pots on a circular track, and the matter is broken by hand, loaded on wagons and hauled to the railroad for shipment to the refining centers.

The smelting plant has been out of commission for several weeks, on account of a gas explosion which recently occurred in the long brick flue between the blast furnace and the chimney on the hillside, blowing out a section of about 100 feet. Fortunately no one was hurt. Everything was running smoothly when the explosion occurred.

UTILIZATION OF FIRE DAMP AS FUEL AT SARREBRÜCK[1]

[NOTE — The employment of mine gas for firing boilers is unique, so far as known to the editors, and at a coal mine bespeaks an economy which American managers might emulate with profit. The inference of the author, that one of nature's gas factories has been tapped, and not a mere reservoir, is a valuable suggestion for the student of mining problems.—EDITOR.]

An occurrence, which may furnish some indications as to the location of fire damp in coal deposits, took place about eighteen months ago at the Frankenholz Mines, located at the northeastern end of the Sarrebrück Basin. The Frankenholz Mining Company has authorized me to publish a few data on this subject. I am pleased to express here my thanks to the managing directors.

GEOLOGY

The coal-bearing measures of the property worked by the Frankenholz Mining Company are divided into two portions by an important fault, running approximately from northeast to southwest, with a strong dip towards the north. The productive portion of the coal deposit is north of this fault, and above its plane. South of the fault and below it the ground is very much shaken and pushed upwards. In a long exploratory drift from pit No. 1 towards the southeast, gray and red gritty strata have been found, containing fossils which, according to the opinion of Mr. Zeiller, place these strata in the Autunian period. Messrs. Bergeron and Weiss have assumed from this condition of the strata that the Autunian sandstones form an anticline upon which the coal measures of Sarrebrück rest, and that the Sarrebrück Basin, in its entire extent, is merely a heavy surface deposit, whose southern margin at Frankenholz should correspond to the crest of the Autunian sandstone anticline. Whatever may be the case, the principal fault to which I have just alluded is accompanied in the region northeast of pits No. 1 and 2 by numerous very regular, but unimportant small fractures, affecting the coal measures. In the region situated west of these pits, however, it appears that another fault is encountered, grafted on the first one. The plane of this is nearer the vertical and runs east and west. This other fault is, properly speaking, a coördination of small faults of the same direction and dip. These fractures have limited, in the upper levels, the working of the coal seams to the south, because of the proximity of the southern borders of the property. As the workings became deeper, the dip of the faults toward the north gradually reduced the workable area between the faults and the property line. It therefore became of importance to penetrate

[1] A paper read by Henry Joly, Doctor of Science, Professor of Geology of the Lorraine District of the School of Science, at a meeting of the Société de l'Est, translated by A. de Gennes.

A typical "Boulder" Quarry

THE GRANITE INDUSTRY OF BARRE, VERMONT

By George H. Gilman [1]

To those interested in rock products, "Barre" means "Granite," for this enterprising city has the distinction of leading the world in its output of that stone, amounting in the year ending in June, 1909, to above 250,000 tons.

Barre lies in a beautiful valley, in Washington County, 71 miles north of White River Junction, in central Vermont. Shipping facilities are provided by the Montpelier and Wells River Railroad, which connects with the Boston and Maine at Wells River, 40 miles to the east; and by the Central Vermont, via Montpelier Junction, seven miles northwest of the city.

HISTORY

The quarrying of granite at Barre dates back for nearly a century, when mill stones were cut from a hillside now known as Millston Hill, and where, at the present time, the majority of the quarries are situated. Many of them were opened up long before the machinery of to-day was thought of, and there still remains evidence of the early methods then employed, when the stone was split by wooden plugs driven into a slot channeled several inches deep, and expanded by water.

Although it was known so early that the Barre hills contained granite of superior quality, the distance from markets was long a hindrance to development. The population in 1840 numbered 2126, in 1860, 1839, and in 1880, 2060. But in the decade from 1870 to 1880 the foundations of the stone industry had been laid, and with the coming of the Montpelier and Wells River Railroad, the town grew to 6800 in 1890. Since then the growth of Barre has been steady and substantial, fostered by added railroad service, the development of machinery, and the increasing reputation of it sproducts. The population is now over 13,000.

[1] Claremont, N. H.

A typical "sheet" Quarry

THE QUARRIES

There are to-day about 55 separate quarry workings, owned by 22 different concerns, and scattered over an area of about two square miles. These quarries may be divided into two classes: "sheet" quarries, in which, as implied, the stone lies in sheets or layers, approximately horizontal, and increasing in thickness as greater depths are reached; and "boulder" quarries, in which the joints are irregular and often crowded together. The photograph on this page is a good example of a sheet quarry, and that on page 358 shows part of a boulder quarry.

The granite quarried throughout the territory varies little in the proportion of the constituent minerals, namely *feldspar*, quartz, and mica; and upon the amount of black mica depends primarily the grades of dark, medium and light stock known to the trade. In color it is gray, or bluish gray, and is very free from imperfections, such as streaks or discolorations. This fact permits the quarrying of uniform stone of any size up to the limit of transportation. Barre granite is remarkable for its beauty in the rough and in polished forms. Its ability to resist weathering and to continue to look clean and bright after exposure is famous, as well as its wonderful adaptability to tool treatment.

At the extreme north of the territory covered by the quarries, the stone is lighter in color and of coarser grain than at the south, although, as compared with other fields, none of the granite found would be termed coarse grained.

Despite the extreme cold of the Vermont winters, the quarries are operated throughout the entire year, thus giving steady employment to over one thousand workmen.

QUARRY METHODS

Although the methods of working the sheet and boulder quarries differ in many respects, it is necessary in either case to partially free the stone from the bed or mass by channeling, to avoid unnecessary fracturing of the rock when blasting is resorted to. In this system holes are drilled in a line usually about 2½ inches apart from center to center, leaving a

Present-day Method of Drilling "Plug" and "Foot Holes" (Sullivan Drills in Boutwell, Milne, Varnum Quarry)

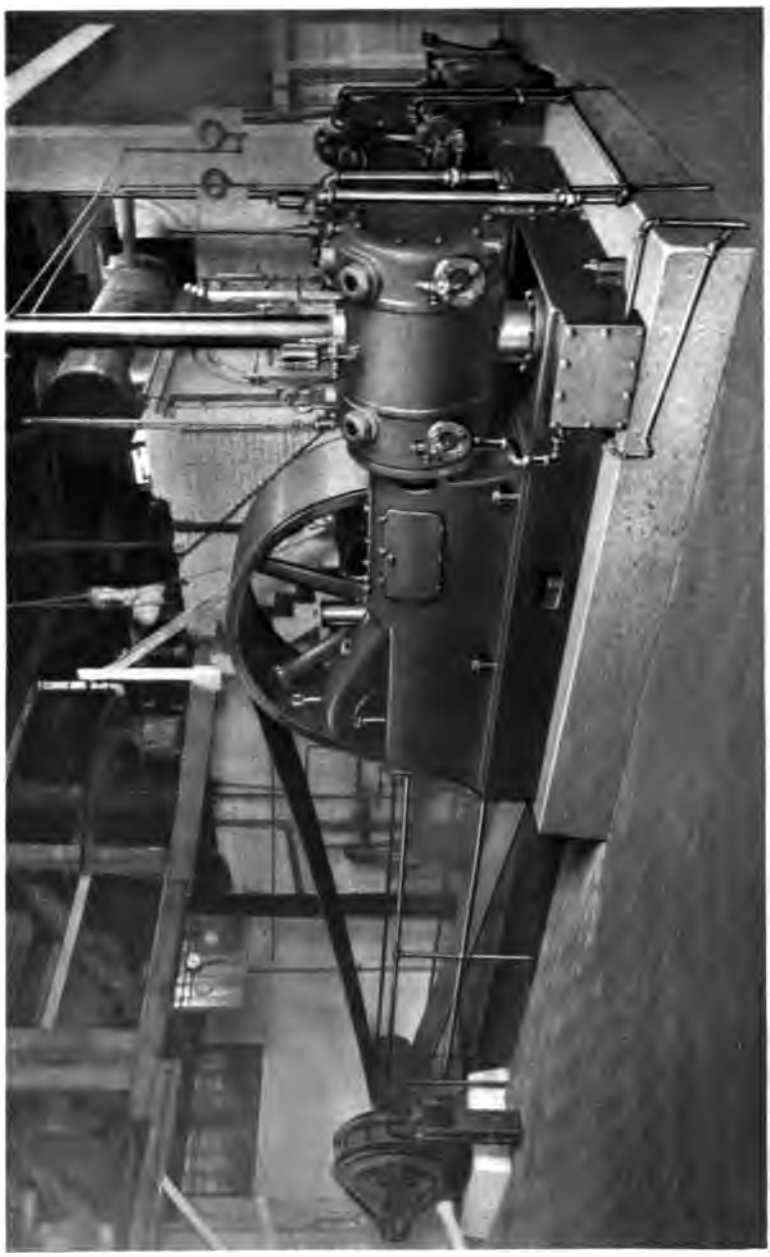
Method of Drilling "Plug" and "Foot Holes" before the day of the Hammer Drill

''Foot Hole'' Drill at Work in a Granite Quarry

Channeling granite with the Sullivan Rock Drill and Quarry Bar

Sullivan Breaking Tool, Barclay Brothers

Sullivan Block Hardener Channelling across the end of a long block, Barclay Brothers



Sullivan "WJ" Air Compressor, Barclay Brothers, Barre, Vermont

ing formerly done by hand is now accomplished by pneumatic machinery.

The block is first delivered to the battery of pneumatic surfacing machines (see page 367) located at the extreme north end of the plant and separated from the main room by a partition with large sliding doors.

On straight work these surfacing machines are adapted to cut the stone, from the condition in which it is received, while in the case of curved surfaces, lines are first chiseled or hammered around two or four edges, the balance of the surface being roughed down by plugging and bull setting to within two or three inches of the finished size before it may be worked to advantage by the machines. It is a fair estimate to say that one of these machines will do the work of six men surfacing by hand.

Here the block is formed to the required size, to a hammered finish. After the stone is surfaced it is transported by a crane to different parts of the works, where it is carved, sawed, polished and worked to completion.

Barclay Brothers' plant has in all about 70 pneumatic machines, ranging in size from the smallest of carving tools for delicate lettering and statuary to the large crane surfacers.

The air compressor is a Sullivan duplex two-stage, belt-driven machine, with a capacity of 1056 cubic feet of free air per minute, and is the largest belt-driven compressor in the district. The main working parts are oiled automatically by the "splash" method, and are enclosed to keep out grit and stone dust. A 150 H. P. motor transmits the power required to operate the compressor through a 28-inch double leather belt. The air is compressed to a terminal pressure of 105 pounds per square inch, and is piped to four large receivers, located in different parts of the plant. For the surfacing machines, plug drills and pneumatic polishing machinery the air is used at this pressure, but is reduced to 70 pounds for the smaller hand tools.

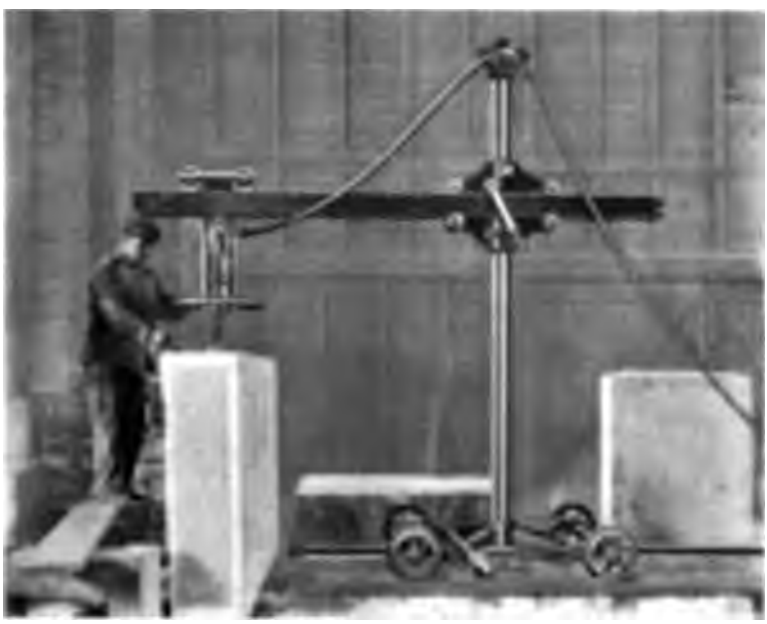
Sullivan hand surfacers are used for finishing the small surfaces which would be inconvenient to place under a larger machine. In connection with drills and channeling tools, they are used for such work as Lewis-holing, cutting mortises for cross tenons, cutting out solid sets of steps, buttresses and large rabbets. They are also used for channeling sinkages around columns and pilaster dies and forming sinkages for large cornices and gable stones, thus dispensing with much risk in cutting.

Electric power is used exclusively, there being nine motors ranging from 5 H. P. to 150 H. P. Four lathes for turning and polishing columns, balusters, vases, balls, etc., are located at the south end of the building, and also the gang saws and polishing machinery. The polishing machines are adapted for polishing a granite block of any size or shape.

A 125 H. P. boiler capacity is used, in connection with a blower system, for heating the plant in winter. The blower is also used, during extremely warm weather in summer, to create air circulation.

The pioneer Pirie sharpening machine is located in this plant. Operated by two men, it will keep 100 granite cutters equipped with cutting tools and will do the work of seven men, sharpening by hand.

Testing a "Plug" Drill



often only 500 to 700 feet of core. If the cost per foot drilled is $2.50, the cost of the core will run from $3 to $4. It is, therefore, important to make as much as possible out of the core and the various lines and bands crossing it, whether they represent the bedding or represent displacements which may affect the record. The proper interpretation of these lines and bands is not always an easy matter. In the first place, the hole itself is liable to vary in direction. In the second place, generally speaking, we do not know the position of the core. A line or plane cutting it cuts it at an angle which can be measured. But in what direction that angle is from the core is usually not known. Little attention has been given to the marketing of core so as to know its exact position, — to know, for instance, the lowest side of the core taken from an inclined hole, though it is not impossible to do this.

If the core is crossed by lines of bedding, and we know from surface observations, what the direction of that bedding is, we can then tell how the core stands, and with that information can definitely determine the direction of other lines that cross it.

It is customary, as we have said, to put down holes at right angles to the dip, and often diamond drill holes are arranged in a series, so as to make a section across the formation. There is another advantage, beside the two above mentioned, in doing this, that errors are of less importance. The errors in thickness of a hole supposed to be put at right angles to the formation, but really deviating as much as 15° therefrom are but one-thirtieth and a deviation of one-third as much will have but one-ninth the error.

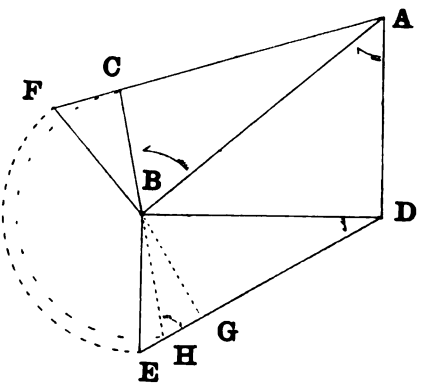
But occasionally, through unforseen quirks in the formation, holes are far from perpendicular to the formation to be tested. Of course, holes are sometimes deliberately put down with the formation to prove up the average quality of a chute, and put down vertical, even though the strata are highly inclined. In that case it is not always a simple job to compute just what the strike and dip of a formation are, even from a number of holes, though these are of vital importance, and there is a temptation to use approximate methods, beyond the limit of even approximate accuracy. I gave a discussion of a number of such problems that arise in my report on Isle Royale — Geological Survey of Michigan, Vol. VI, Part 1. 1899.

At the invitation of the editor of MINE AND QUARRY, I propose, in a series of papers to give as I have time, solutions of problems *which have actually arisen* in the past ten years. I shall try to make the solution so plain that any one who has similar problems can readily apply the same method.

PROBLEM 1. AT WHAT ANGLE WILL A PLANE (OF FAULT OR BEDDING) WHOSE STRIKE AND DIP ARE KNOWN CUT THE CORE OF A DRILL HOLE WHICH MAY BE INCLINED A KNOWN AMOUNT IN A KNOWN DIRECTION?

We will first solve this problem by drawing it out.

Let AD be the strike of the fault. Lay that off to have any convenient length and direction. Make on it as a side, erecting a perpendicular to AD at D, the right triangle ABD, taking B so



Drill Core Problem

AT PANAMA

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MINE AND QVARRY

Vol. No. 4 APRIL, 1910

DRAINAGING IN THE PANAMA LOCKS

WORKING A STEEP COAL SEAM

CHANNELED WALLS AT PANAMA

A GRANITE MARBLE QUARRY

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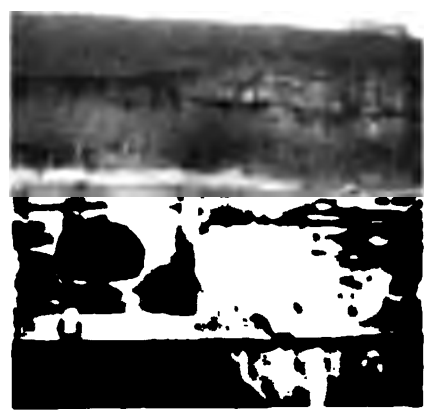
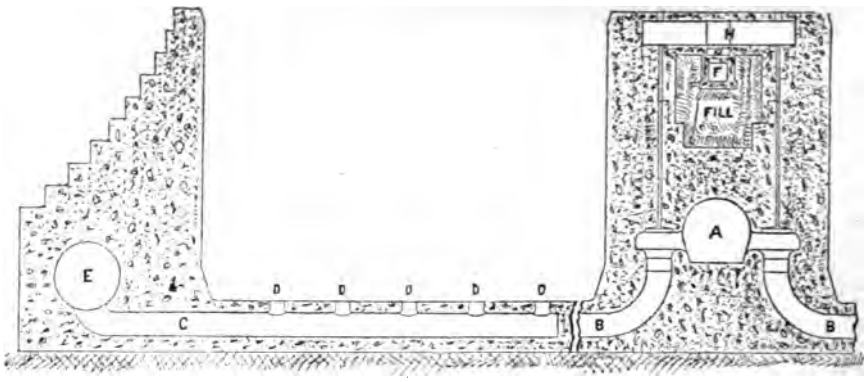
[illegible] AND OVARY

Completed excavation for the Pedro Miguel locks: Sullivan channelers and rock drills at work.





Cross section of lock chamber and walls, Gatun Locks.

A Culvert in center wall.
B Connections between center and lateral culvert.
C Lateral culvert.
D Wells opening from lateral culverts into lock chamber.
E Culvert in side wall.
F Drainage gallery.
G Gallery for electric wires.
H Passageway for operators.

From the Canal Record.

Under such conditions it is very desirable that the floor between the trenches shall be disturbed as little as possible. In order to eliminate the shattering effect of blasting it was decided to cut the side walls of these trenches with stone channeling machines. For this work Sullivan rigid-head channelers with 8-inch cylinders were adopted and 24 of these machines are now on the Isthmus. The photograph on page 370, shows six channelers at work at Pedro Miguel, and gives an excellent idea of the lock site, in which the excavation was nearly completed at the time the picture was taken.

The channelers are run by compressed air from the power plant at this end of the Culebra cut, and are equipped with air reheaters. The solid "Z" shaped bit is used altogether, owing to the "wild" character of the ground.

Page 373 shows a channeler at work at Mira Flores. Here the air-pressure is very low, 40 pounds. The channelers cut to a depth of 10 feet, and average 120 feet per eight-hour shift.

The cut on page 393 shows a channeler at Gatun, equipped with a boiler. The machines here are run by steam, as no air-power is available.

In addition to preserving the surrounding rock intact and unshaken, the use of channelers has resulted in a large economy of concrete, owing to the fact that the excavation is confined strictly to line.

The rock between the channel cuts for the lateral culverts is drilled with Sullivan 3⅞-inch drills and shot lightly, to break it up for excavation. As soon as the rock is removed the forms for the culverts are placed and the trench filled with concrete. The photograph on page 371, shows one of the trenches, with the culvert and concrete work partially completed.

The total amount of channeling to be performed in the locks is about three quarters of a million feet, and includes cutting trenches beneath the curtain walls and across the forebay at Gatun. In these trenches cut-off walls are being built to divert underground waters, whose presence has been discovered, from the area below the locks. In this case also it was of the greatest importance that the adjacent ground should not be disturbed by blasting, so as not to affect the stability of the foundations for the great concrete lock walls.

The channeling of the lateral trenches in the upper locks at Gatun is completed, and will be taken up in the intermediate and lower flights as soon as the excava-

A Bullivan excavator at Mira Flores.

tion is sufficiently advanced. At Pedro Miguel the trenches are about 90 per cent channeled, while at Mira Flores this work is progressing rapidly in the upper locks.

DESCRIPTION OF LOCKS

Excavation for the locks began in the fall of 1906, and is now about 60 per cent completed. Another year will be needed at Mira Flores to remove all the material down to floor level. The placing of concrete in the floors and walls of the locks at Gatun and Pedro Miguel began about September 1, 1909, and is progressing rapidly under the efficient system which has been installed. Up to March 12, 1910, 252,511 yards had been placed at Gatun, out of an estimated total of 2,086,000, and the work is proceeding at the rate of about 2,800 cubic yards per day. At Pedro Miguel, about 71,000 yards had been placed up to the same date.

The locks will have a uniform inside length of 1,000 feet, a width of 110 feet, and a depth on the mitre sills of 41½ feet of water when the surface of Gatun Lake is at its theoretical normal height of 85 feet above the ocean. The side walls will be 30 feet thick at the floor line, and from a point 24½ feet above will be staggered on the outside face to a summit width of eight feet. The central wall, between each pair of twin locks, is to be 60 feet thick, and from a point about half way up will be narrowed toward each face to provide a tunnel or space for drainage, electric cables for the valve and gate machinery, etc. See cross-section sketch on page 372.

Sullivan "Post Puncher" starting a mining in the Coal Creek Mine.

"Post Puncher" in the Coal Creek Mine, with 90-inch extension in use.

Setting up a "Post Puncher" in a 36-degree seam.

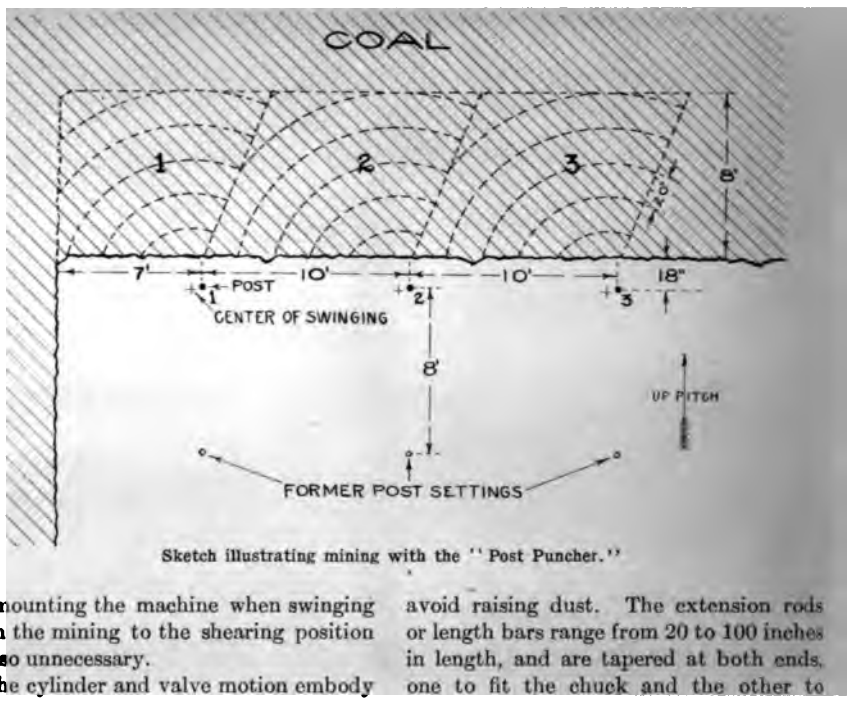
to the Sullivan Post Puncher, and after several months' use an order was placed for 30 machines of this type and make.

THE POST PUNCHER

The pictures on pages 374 and 376 show a "Post Puncher" in operation in the No. 2 vein of the Coal Creek mine, where the coal is 4½ feet high, and pitches at an angle of 38 degrees. As this type of mining machine is practically new in American practice, a brief description may be of interest.

The "Post Puncher," resembles a rock drill in the fact that it is mounted on a post or column, and uses length bars or steels of various lengths, in doing its work. It resembles the "puncher" or pick machine in its ability to mine across the face, or to shear a room from top to bottom. For this purpose the machine and shell are mounted on a gear segment, controlled by a worm and crank. In mining, the operator swings the bit to an arc back and forth across the face. By loosening one nut, the segment may be set in a vertical plane, and a shearing cut made in a similar manner.

This feature is a very great convenience when the coal will not shear readily unless both mined and sheared. A valuable feature of the "Post Puncher" is the fact that the machine does not swing around the post, but around the center formed by the socket, in which it is clamped, about six inches from the post. It is, therefore, unnecessary to set the column exactly square with the intended mining, but the machine may be set in a few seconds to mine wherever desired, regardless of careless planing of the post. This is a patented feature, possessed by no other similar machine.



Sketch illustrating mining with the "Post Puncher."

Dismounting the machine when swinging from the mining to the shearing position is also unnecessary.

The cylinder and valve motion embody other novelties. The front head is solid with the cylinder, thus eliminating the complication of side rods. When the coal is missed, the piston will overrun the front port and stop, thus obviating damage to the front head. This overrunning occurs very seldom with a skilled operator, but the delay attendant on feeding the machine against the coal, so that it will start again, is nothing to the delay due to breakage that would occur eventually if the piston could strike the front head. The cylinder is made of steel, to resist the heavy shocks and strains received from falling coal. Felt packing of a very durable character and having an adjustable gland, is employed. A combined shell adjustment and stop, to prevent feeding too far, and a rotation without springs, provided with five round steel pins or pawls, are other interesting features of the "Post Puncher" design.

The exhaust cap is so arranged as to throw the air in any desired direction to avoid raising dust. The extension rods or length bars range from 20 to 100 inches in length, and are tapered at both ends, one to fit the chuck and the other to receive the bit holder. This bit holder has tapered holes for from three to seven chisels or bit points, as shown on page 374. A solid bit may be used instead, depending on the nature of the cutting.

The mining may be put in at any desired height in the seam, so as to mine in fire clay, the coal itself, or in a dirt band, by raising or lowering the clamp on the post. In the illustrations the machine is shown mining in a band of bone and clay near the roof, and is accordingly above the segment. In the six-foot "Muldoon" vein, the impurities are lower in the seam, and the machine is hung below the segment.

METHOD OF OPERATION

The rooms are driven 45 to 50 feet wide. The first cut is made from a post set seven feet from the left rib and about 18 inches from the face. See the sketch on this page. A mining eight feet in depth is put in, using an extension bar 80 inches

Loading Coal in Waldeck Vein. Note man at chute in rear.

long. The chunk enters the cut, which accounts for the mining being deeper than the length of the extension. After the 66-inch extension has been swung, a 100-inch bar is used to square up the cut. One man operates the machine, swinging it by means of the worm crank with one hand, and feeding the cylinder forward two or three turns with the other, at each end of the swing.

Although the cuttings fall out of the cut without scraping, due to the pitch, a helper is required to set up, pick down coal, shovel. When the operator is completing the left rib cut, the helper sets up a second post about 10 feet from the first one, or about 17 feet from the left rib, and 18 inches from the face. Upon finishing the rib cut, the machine and swinging attachment are transferred to the second post with only a few minutes' delay. While the operator is making the second cut, the helper takes the first post down and resets it about 27 feet from the left rib for the third cut, and so on, until the face is crossed. Only a half swing is used, so that the operator is protected by the unmined coal, as well as by the machine itself, from the coal loosened from the face by the mining.

The machine and posts remain in the room at the face until the room is completed, for there is no shooting of the coal that can injure the machine nor any loading (as in a flat seam) that the machine would interfere with. Hence there is no waste of time due to moving, except from post to post, and little heavy lifting. Two men can set up with ease, as the heaviest parts (the machine and shell) weigh only 225 pounds.

ECONOMIC RESULTS

These machines average about 300 square feet in an eight-hour shift, or from

Top works and town of Coal Creek.

Bottom of slope, Coal Creek Mine.

flatter seam, where the danger to the operator and machine from falling coal is less serious, the machine is used to cut on both sides of the post, from the same setting, having a maximum capacity of about 18 feet of face from one set up. To keep the ribs or side walls of an entry or room straight, the bit is swung back and forth across the corner, gradually advancing it with the feed screw until the angle is square. Or a hole may be drilled at the extreme end of the swing to the full length of the feed screw, then the bit cranked back and the mining made up to this hole at each swing.

WEDGING DOWN COAL

The Post Puncher may also be employed for wedging down coal, in mines where the use of explosives is prohibited. After undercutting and shearing, the machine drills a hole about three inches in diameter at the top of the seam. An ordinary bit may be used for this purpose. The hole is then scraped out and a compound wedge (plug and feathers) inserted. The machine may be swung around the post if necessary to give access to the hole. When the plug and feathers are placed the machine is swung back to position opposite the hole, and a special hammer inserted in the chuck. The air is gradually turned on, the hammer striking the wedge with increasing force until the coal breaks down.

RAISING A MINE SHAFT

Contributed

It sounds anomalous to the layman to hear of a shaft which is driven up from below, instead of downward from the surface. Yet this has become a widely accepted method, under certain conditions, and has many advantages over the orthodox system.

Generally speaking, shafts are "raised" when a new opening is desired for a developed mine, or when one of two or more shafts, connected by drifts or levels, is to be extended. The method employed consists in driving to a point directly under the proposed opening, whence a small raise is started, which is enlarged later to full size. The muck is dropped into cars on the lower level through a chute, and hoisted through the existing shaft, or used to fill up rooms or workings from which the ore has been removed.

In the Lake Superior district, instances are on record of three compartment shafts which have been raised in their full size and timbered at the same time, instead of driving a small raise and stripping it later. In these cases the timbers were placed with the aid of a small hoist, installed at the bottom level. To prevent damage to the timbers, two compartments were kept full of muck. The third was used as a manway and for ventilation.

In the soft iron ore fields of northern Michigan, raising is sometimes employed to extend a single shaft driven in the foot wall. At a convenient point on the bottom level, a winze is sunk in the ore to the proposed depth, and from its foot a drift is run to a point below the center of the shaft. Raising is then started, a chute built, and the dirt handled through the winze, where it is either stored or hoisted from the old bottom level. Ventilation is provided by a small blower.

Sinking the winze in the soft ore is an easy and simple task, and cannot be classed as dead work.

ADVANTAGES OF THE SYSTEM

Much time and labor is saved, by the raising system, in handling spoil. After a round of holes has been shot in a shaft sunk by the usual method, it is necessary for shovel-men to load the spoil out, before the drills can get to work again.

When raising, no shoveling at all is required, as the muck falls down the chute and is loaded by gravity into the mine cars, in which it is hoisted directly to the surface, or from which it is dumped in a worked-out chamber. No time is lost by the drill men in waiting for the muckers, since the overhead face is always free, and ready for the next round, as soon as the powder fumes are blown out and enough spoil dropped down the chute to permit entrance. The number of rounds that can be drilled per day or month is therefore much greater in a raise than in a shaft sunk in the customary way.

Where a shaft is in active production, it may be extended by an upraise from a lower level without interruption to the regular hoisting service, and without placing the men engaged in the extension in danger from falling material or from accidents to the hoist. If in water bearing ground, the pumping problem is much simplified — in fact, the "sinking pump" is eliminated, just as shoveling is eliminated.

HAMMER DRILLS

Another and equally important advantage lies in the use of air feed hammer drills for raising. Before their use became general, great loss of time and much heavy labor were involved in handling piston drills. Much time and work were expended in hoisting the drill and its mounting up and down the raise.

The advent of the light "one-man" hammer drills, which require no mounting and no support other than a footing of muck or a block on which to rest the air feed cylinder, has occasioned remarkable economy in work of this character.

In addition to the gain in actual drilling time made possible by the fact that no "set up" of a separate mounting is required, there is an increase in efficiency on account of the ability of the runner to point his holes in exactly the right direction to pull the rock to the best advantage.

Raising with a Sullivan Stoping Drill.

Stoping drills, including those of the Sullivan "D-21" pattern, are used for this class of work with eminent success in the Lake Superior district. In the winzes driven in ore, above described, Sullivan "DB-19" air hammer hand feed sinking drills have also proved satisfactory. In a later article, more specific data will be furnished as to the use and performance of hammer drills in work of these kinds.

The Main Quarry Pit, Missisquoi Marble Co.

A QUEBEC MARBLE QUARRY

Special Correspondence

The property of the Missisquoi Marble Company comprises about 300 acres of quarry lands, at Phillipsburg, in the province of Quebec, two miles from the Vermont boundary line, and bordering on Lake Missisquoi, one of the northern arms of Lake Champlain. This deposit of marble is apparently independent, being over 130 miles distant from those in St. Lawrence County, New York, and more than one hundred from the Vermont marble district about Rutland.

Thorough core drilling has shown that the marble formation covers practically the whole of the company's property, and that it is sound and of excellent quality. Its chemical composition is as follows:

	Per cent
Calcium carbonate	96.34
Calcium sulphate	0.12
Magnesium carbonate	0.49
Silica	1.18
Iron oxide and alumina	.80
Undetermined, etc	1.07

The stone is of handsome appearance, being gray with green veins, and cream with green veins. There is also a layer producing green with a little pink.

Tests were made in a very systematic manner upon samples submitted for the purpose to Prof. H. M. Mackay of the department of Civil Engineering at McGill University, Montreal.

The compression tests were made in the Wicksteed machine upon two-inch cubes. The "Windsor Gray" samples withstood a pressure of over 21,000 pounds and the "Eureka" cream color stone, a pressure of nearly 23,000 pounds per

The Quarry and Traveling Crane.

square inch. This compares favorably with the better grades of granite. The absorption of moisture, as shown by a test upon roughly broken samples, is remarkably low. The specific gravity is 2.71, or 169.5 pounds per cubic foot.

These marbles are employed extensively for monumental purposes and for interior decoration, and more recently have been used for building exteriors, with highly satisfactory results.

The deposits lie in regular beds or layers, sloping at an angle of 45 degrees. The surface material or overburden is only a few feet in thickness, making stripping a simple problem. The views on this and the preceding pages show how the quarry is being developed. The property was originally purchased about 15 years ago, by the Phillipsburg Railway and Quarry Co. It was not until 1906, however, that work was begun, and in 1907 the present owners acquired possession. Since that time, progress has been rapid.

Quarry Methods

The marble is quarried with nine Sullivan swivel-head channeling machines, operated by steam through swivel piping. Five of these are of the Class "6½" type, two Class "Z," with seven-inch engine cylinders, and two Class "VX," for light work. These channelers possess adjustments enabling them to cut at any desired angle, so as to enlarge the quarry floor by "undercutting," as illustrated in the left-hand wall, above, or to cut cut ends and corners, illustrated by the left-hand machine on page 384. The wall cuts are put in at an angle of 70 degrees. These channelers cut ordinarily to a depth of six feet, and 65 square or channel feet are considered a fair day's work in this hard, dense marble. The blocks are

broken away from their beds by wedges, driven in holes bored in line with the dip by Sullivan Rock Drills, mounted on a quarry bar. A Sullivan "foot-hole" hammer drill is used for pinning down track and other miscellaneous purposes.

A novel method is in vogue for handling the blocks. Instead of the customary boom derricks, or cranes, a traveling electric crane is installed with a span of 100 feet and a lifting capacity of 30 tons. The runway is 460 feet long. This crane provides an unusually rapid and economical means of loading cars for the finishing plant and of moving the channelers and drills about the pit. A second crane is now being installed in front of the mill to handle the stone to and from the saws, and in the finishing departments.

From the quarry, the blocks go to the storage yard, which is under a traveling steam derrick, and connects with the mill and finishing works. The mill contains six gangs of saws and a steam-driven air compressor, which furnishes power for pneumatic tools of various kinds, and for pumping water from the artesian well, from which the quarry supply is drawn. In the finishing shop are two rubbing beds, two polishing machines, a planer, lathe, etc., while another building contains electric-driven Scotch circular saws.

The steam boiler plant provides 500 horse-power, for the channeling machines, drills, and for an engine and direct-connected generator, which drive the crane, gang and circular saws, and the machinery in the finishing room.

The plant also includes a blacksmith shop, supply house, stables, and a number of houses built for employees, who number about 140 at the present time.

The Missisquoi Marble Company owns a controlling interest in the Phillipsburg Railway, running from the quarry to Stanbridge, where it connects with the Central Vermont and with the Canadian Pacific System. A branch of the road links the property with its wharf on Lake Missisquoi, whence water communication is uninterrupted to New York City, up the Erie Canal, or by the Richelieu River to St. Lawrence River ports.

Channeled wall in a quarry.

Although the company has been in operation only two years, its product has been widely used. Among the larger buildings in which it figures as interior finish are the Windsor Hotel and the Emanuel Church in Montreal, the Royal Bank in Toronto, the Second National Bank in Cincinnati, St. Jsoeph's Hospital at Victoria, Bank of Commerce, Vancouver, the Post Offices at Vancouver, Regina and Edmonton, and the Hudson County Court House at Jersey City, N. J., Missisquoi marble was used for the exterior of the Workman Building in Montreal.

Mr. F. W. Richardson of Kingston, Ontario is the president of the company, and Mr. Henry Timmis of Montreal is managing director. Mr. Henry Brown is resident manager at Phillipsburg, Mr. S. N. Nickle, quarry superintendent, and Mr. S. G. Timmis, mill superintendent. The courtesies of these officers in furnishing information for this article are acknowledged with thanks.

DIAMOND DRILLING AT TONOPAH

By Jesse M. Fox[1]

(Extracts from an Article in the Mining and Scientific Press)

In the autumn of 1908 it was decided to put down a vertical drill-hole from the bottom, or 700-foot level, of the Silver Top mine to gain information regarding the formation through which the Silver Top No. 2 shaft would have to pass if sunk to greater depths. A station and raise were cut close to the shaft and the drill installed. The height of the raise was sufficient to enable the runner to pull in 20-foot lengths. A suitable sump was cut near by for return-water from the hole, thus permitting the use of the same water repeatedly, with the exception of what was lost in the hole.

The drill was a Sullivan Class "C," provided with a hydraulic head and chuck for size "A" rods, capable of drilling to 1500 feet. The engine, drum, and head were mounted in the usual manner, on a standard frame, which was held in place by two heavy spurs wedged to the wall of the station. Compressed air at 90 to 100 pounds pressure was used for motive power, it being tapped from a main line through a 1-inch connection to the engine. As the level is dry, water for the drill was drawn from the water-pipe line in the shaft. Since a 700-foot head would have provided a higher pressure for the drill than was desirable, a break in the line was made at the 400-foot level. A large sheet-iron tank was installed at that point, and the supply-pipe from above was provided with a valve that was opened and closed automatically by a float. From the tank to the drill approximately 300 feet gave about 125-pound water-pressure, sufficient for the ordinary operations of the feed. In actual running, the hydraulic head was supplied entirely from this source, proving perfectly satisfactory, as it gave clean water at a constant pressure with no entrained air.

The latter is objectionable, giving rise to "jumping" in the rods, with attendant extra wear on the diamonds. As stated above, the water at the bit is used many times. As it flows from the collar of the hole, it is collected in the sump, and from there pumped by a small duplex back through the rods. The supply, of course, has to be replenished from time to time, as some water is lost.

At the start, the hole was reamed to a depth of three feet, and a two-inch inside diameter pipe wedged in it. This projected high enough above the collar to allow the sludge-board to be placed, when actual drilling began. Size "A" rods (standard), having an outside diameter of 1⅝ inches, were used. To these were strung a ten-foot, size "A," plain core-barrel, straight core-shell for "Cassetta" core-lifter and size "A" bit. The latter

Sullivan Diamond Drill, Tonopah Mining Co.

[1] Assistant Superintendent Tonopah Mining Co.

has an outside diameter of 1 $\frac{23}{32}$ inch. With the carbons having a total offset of $\frac{1}{32}$ inch, the diameter of the hole, assuming a perfect bore, would be 1 $\frac{15}{16}$ inch.

The diamonds or "carbons" used averaged, when new, about 3½ karats each. They were of the best quality, and at the existing market price cost $75 per karat. Six stones were set in each bit, three inside and three out, with a $\frac{1}{4}$-inch offset. The life of a new bit varied greatly in this hole; some drilled 35 to 40 feet before becoming played out, others were retired after drilling only two or three feet. Many causes contributed to this difference in life. Vibration in the rods causes great wear and tear on both stones and metal. Short-fissured ground makes bad drilling, and variable pressure at the feed, which is hard on the bit.

On account of certain conditions obtaining in the case of this particular hole, but one eight-hour shift was employed. The crew consisted of a runner and helper.

As is customary in drilling, no stop was made at the lunch hour, the helper running the machine through that time. The shift went on at 7 A. M. and ceased at 3:30 P. M., unless it was deemed advisable to work through to 5, which was done many times. The runner set the bits after 3:30, and whatever repairs had to be made on the drill or pump were attended to by the helper after that time. All such overtime was credited to the crew on the scale of straight time, being figured to the nearest quarter shift.

With this outline of equipment and labor, we will consider the hole itself. Everything went smoothly till at a depth of 87 feet the character of the formation penetrated changed. The ground became broken, and considerable gouge kept cutting off the water. When solid formation was again reached, the hole was washed as clear as possible and Portland cement mixed with water to the consistence of thick cream, was poured into the hole; 72 hours were required for the cement to become hard enough to drill. Some other soft spots were struck that gave similar trouble, and these were treated in the same way. Thus by cementing and drilling out, the hole was lowered to 225 feet, the last fifteen being in firm ground.

Each morning it was found that the hole was caving worse than the preceding day, and more time was consumed in reaching bottom, the rods often having to be rotated while washing their way down. Finally, at 225 feet, the rods stuck fast; hydraulic and hoist failed to start them, so an improvised jam was made by slipping a 5-foot length of 6-inch pipe over the rods; to the pipe was fastened a rope leading over a sheave, and down. The pipe was snapped up, striking a clamp bolted securely to the rods; the latter were thus released, and when all were out, it was decided to ream to 210 feet, and case with 2-inch inside diameter pipe. This was done in the usual manner, using a reaming-bar, bit, and pilot, and following with casing instead of rods. After the last run was made, the bar, bit, and pilot were removed. A few carbon chips were set in the face of the bottom length of casing, and the latter sent home to its shoulder at 210 feet. The chips provided a means of cutting away slight obstructions that might get in the way while lowering the casing for the last time. They were worthless for any other purpose, and hence were left in the hole. From here on, work progressed without serious trouble, occasional soft streaks being cemented; at 411 feet the water was lost completely; in fact, it ran away so rapidly that the sump was siphoned dry. Sawdust and bran proved ineffectual in plugging the outlet, and until cement was used, the water continued to escape.

Experience gained in cementing sections of this hole may prove of use to others. In the first place, certain brands of cement are more adaptable to this work than others. Those reaching their initial and final set the most rapidly are obviously

NOTES ON DRAINAGE TUNNELS IN PENNSYLVANIA

Sullivan Rock Drills in the Mauch Chunk Drainage Tunnel.

June, 1909. It is about 7,500 feet long and constitutes the outlet to the Lehigh River for what is known as the Buck Mountain gangway, a series of passages about 13 miles in extent, now being driven to drain fourteen different collieries in the Panther Creek basin, between Mauch Chunk and Tamaqua.

The tunnel was driven by the Portland Contracting Co., of Pottsville, Pa., who set a record, for this region, of 349 feet of single heading advance during one month on this enterprise. Sullivan "UH" 3⅝-inch drills were used.

The same contractors have also finished (in December, 1909) a tunnel 4,935 feet long at Oneida, in Schuylkill County. This waterway is doing the work of five large pumps at the mine owned by Coxe Bros. & Co., Inc., and operated by the Lehigh Valley Coal Company.

The water passes through the Tomhickon Valley by way of the Catawissa and Susquehanna Rivers. The tunnel has been driven through solid rock, consisting of hard conglomerate, close-grained blue stone, and red shale, in about equal portions, all fairly hard drilling. The inside or mine heading was begun in May, 1908, and the outside end in August of that year. The working face is 7 x 11 feet, with a ditch at one side 2 x 1½ feet.

After August, the tunnel was driven with Sullivan "UH-2" drills, of which two were used in each heading. In the conglomerate, however, three drills were used. The two headings together averaged 350 feet per month, working one shift. In July, 1909, the two headings were driven 408 feet; in August, 419 feet and in September 410 feet.

An average of 18 holes were drilled in each face, to a depth of about 7½ feet. When fired with about 140 pounds of 60 per cent dynamite, an average "pull"

or advance of seven feet was gained. About 705 rounds or faces were drilled to drive the 4,935 feet of tunnel. The average drilling time per round was 7 hours. From the above figures about 67 feet of hole were put in per drill per seven hours' work.

Each face has 8.9 square yards, so that 20.74 cubic yards of rock was removed by 135 feet of holes, or, a cubic yard was removed by 6.4 feet of drilling.

The contractors have used Sullivan "UH-2" (3⅝-inch) drills in much of their shaft and tunnel work, and have on record some unusually low maintenance costs for these machines on this and other jobs.

PROBLEMS AND METHODS ON A BARGE CANAL CONTRACT

By Wm. M. McKearin[1]

The present Erie canal is the result of what was generally considered in 1817, a visionary dream. It has so well proven its value as a connecting waterway between the Great Lakes, Lake Champlain, and The St. Lawrence with the Atlantic ocean at New York via The Hudson River from Troy, that to-day improvements to the amount of $10,000,000 have been authorized and are now in progress. These improvements will consist of widening and deepening the canal, and in some places changing its course, in order to utilize various rivers and lakes. When this has been completed, it will be possible to deliver lake cargoes at the seaboard in the original vessels, without transferring at Lockport, as at present. Then, too, steam tugs will be used for the most part in place of mules. This will make it possible to handle a great increase of traffic.

Contract No. 40 consists of widening the canal from 70 to 100 feet, deepening it from nine to 20 feet, and building culvert entrances, guard gate, stream entrances, bridges, etcetera, from Lockport locks to Sulphur Springs guard lock, a distance of about five miles.

The canal descends over a cliff at Lockport about 50 feet high, known in geology as the Niagara escapement. This consists of drab colored limestone overlying gray limestone, which in turn overlies shale. The top layer of limestone is soft and filled with pockets of crystals. The gray limestone is more compact and a trifle harder. Occasionally some flint is met with, rendering channeling and drilling difficult; otherwise all three formations are easily worked.

This contract represents $2,166,000 worth of work and was awarded to the United Engineering & Contracting Co., of New York City, in December, 1908. This company in turn sub-let to the Rochester Construction Co., of Rochester, N. Y., the part known as the Canal Quarry C .'s section, and to Bellew & Merritt, of Tuckhoe, N. Y., the berm and harbor sections. The sections sub-let cover a distance of about one mile.

HARBOR SECTION

Following the canal west from Lockport, the harbor section of Bellew & Merritt is first encountered. Steam drills are used to drive holes about 14 feet deep. The steels are sharpened with an "X" bit of 2½-inch gauge for the starters and ¼-inch decrease in gauge for each successive length. The wear is very slight and often a steel is used a full week before going back to the blacksmith. A Sullivan "Y" channeler with boiler is making the wall cuts. The channeling is started one foot above the water line. On the south side of the canal the channeling consists of two cuts each about 10 feet deep. On the north side, one 11-foot cut is being channeled from the present bottom of the canal, which will bring it level with the south side.

[1] Farmers' Bank Bldg., Pittsburg, Pa.

Four Sullivan channelers on the north wall.

All the rock in the new portion of the canal will be drilled and shot out in two benches. The remainder, beneath the old canal bed, will be worked in one bench. The spoil is loaded into cars by a 75-ton steam shovel. These cars are hauled by two dinkey locomotives to a dump about a quarter of a mile away.

Where the channeling was first started, a high, loose bank crowded the stone which was to be cut. Not only this but the rock itself was very much broken up. For these reasons the "Z" solid bit was used.

It has given the best of satisfaction and an average of 86 square feet per eight-hour shift was made. In one shift, 156 feet were channeled and in one forenoon of four hours, 85 feet. The channel was kept free of mud while the steels were being changed, by a steam siphon, made on the job, and connected to the boiler on the channeler.

BERM SECTION

Next in order is the "berm" section, worked by the same contractor. Here also a Sullivan "Y" channeler is in operation. A bench about 16 to 18 feet in height and 36 feet wide is being worked by steam drills. This is removed before the level for channeling is reached. The holes are inclined on a slight angle and placed about six feet apart. Four to six sticks of 50 per cent dynamite are used to spring each of the holes, after which a charge of ten sticks is used for firing. As soon as the rock is shot out, a steam shovel loads it into skips, handled by two locomotive cranes. The cranes place the rock on the spoil bank, about 75 feet back from the prism.

The next section is that of the Rochester Construction Co. A bench similar to the one mentioned, is being removed here by air drills. For quick mudding of the holes before loading, a long one-inch iron pipe is connected to the air line by a hose. It is then lowered to the bottom of the hole and by turning the air on suddenly, the mud is sent flying into the air sometimes as much as 10 or 15 feet. Here the holes were not sprung, but 12 to 14 sticks of powder were used in each for shooting. The spoil is handled rapidly by means of a large steel tipple, mounted on trucks and tipped at a slight angle. There are two tracks running the length

of the framework and on each track is a car with a capacity of six yards. These cars are hauled to the rear end of the track by means of a wire cable and dumped. The entire mechanism is operated by a 100 H. P. motor. The cars are loaded by a 75-ton steam shovel and can make a trip, including loading and dumping, in less than three minutes.

CHANNELING WORK

The Sullivan "Y" channelers with boilers are in use here. Three piece gang steels are used to good advantage. Each bit is 1 x 2¼ inches in size. The gauge of the starters is three inches with a drop of ⅛-inch for each successive length. Owing to the seepage from the canal, the mudding of channels was very difficult until two 3-inch suction diaphragm pumps were procured, and they relieved all the trouble. An average of 90 square feet per eight-hour shift was channeled here during the first two weeks of operation. The best work for one shift was 125 feet.

The work being done by the United Engineering & Construction Co. lies adjoining this section on the west. Rock is being excavated at three points, and earth at about three others. At the first opening, two Sullivan "Y-8" channelers with boilers were put to work. Where channeling was first started the rock was not only very uneven but also very loose and broken up as a result of the blasts. However, the three piece gang was used and fully proved its equality to, if not superiority over the "Z" bit under these conditions. The presence of quantities of flinty spar made progress slow. The channeling was handicapped not only by the conditions mentioned, but by the fact that nearly every cut was started under water, which covered the cut in many places as much as 18 inches.

In spite of the nature of the rock, the channeled wall is solid and straight, and will not be a future source of repair expense. The photograph on page 394 shows this north wall, and the difference between the old blasted wall on top, and the channeled cut below is a powerful argument for the modern method. At this point the canal is down to grade, and the picture shows the excavation completed for about one-half its width.

In order to handle the large volume of water, two electric centrifugal pumps and two air-driven plunger pumps, with a combined capacity of 4,000 gallons per minute were installed, and these were later supplemented by a dam, shown in the picture just behind the steam shovel, and another pump.

The photograph on page 392 shows four Sullivan "Y-8" channelers in the old canal bed, cutting the north wall ahead of the shovel shown on page 394. In the

A Sullivan channeler at Gatun, Isthmus of Panama.

North wall, showing old, blasted, side of canal above, and channeled cut below.

background a gang of 10 Sullivan drills is at work on the bench. The cost of channeling here was increased by the irregularity of the old canal wall, which frequently projected out beyond the surveyors' line, and had to be laboriously trimmed off before the channelers could be put to work. Some idea of the hardness of the rock may be formed from the fact that only about 12 lineal feet of channel per machine could be carried down to grade with success, and even then it was sometimes necessary to use three sets of cutting bits to channel 18 inches, the length of the feed. The channelers are boarded in to give the runners some warmth from the boiler, and protection from the weather.

At the various rock openings, 30 Sullivan "UF" (3¼-inch) air tappet valve drills are in use. While the water remained in the canal the rock was shot out in two benches of about eight feet each but now it is worked in one.

At one opening the spoil is handled by a guy derrick, operated by an air-driven hoist. At another opening, which was directly under a high tension electric line, it required three small air-driven hoists, one stiff leg derrick, and one guy derrick and a car to dispose of the spoil.

POWER PLANT

In the central power house of the United Engineering & Construction Company are installed three 32 x 20 x 30 inch duplex air compressors, each direct connected to a 500 H. P. synchronous motor. The combined capacity of the compressors is 8,400 cubic feet of free air per minute. The air is discharged into after-coolers, from which it goes to two large receivers. From here it is piped throughout the job, a distance of five miles. One of the striking features in the compressor room is the scheme for economizing oil. All oil used, except that in the cylinders, is drained to individual reservoirs in the floor, to the rear of each machine. From these reservoirs it is blown intermittently by compressed air to the filter. On a test run of 20 days, one barrel of 52 gallons

the passage of vessels, so that much of of the work must be suspended during the summer. At the close of navigation in the coming autumn, with all equipment on the ground, and many operating problems solved, the contractors will be prepared to prosecute their undertaking to much better purpose. It is estimated that about two years' work remains to be done.

COST ANALYSIS OF STONE CONSUMPTION IN UNDERGROUND DIAMOND DRILLING

By Benjamin H. Case[1]

The cost of carbons and borts consumed in boring 39 underground holes at the Burra Burra and London mines, Ducktown, Tenn., is shown in the table accompanying this article. The holes were drilled in 1907, with two Sullivan machines of the "S" type, and all but three holes, aggregating 284 feet, were horizontal across the formation. The core was 15/16 inch diameter, and the holes 1½ inches diameter.

The highest cost per foot was $3.66, in a horizontal hole started in the footwall, and drilled to a depth of only 8 feet, consuming 1 61/64 k. of $15 borts. Excepting this hole, which penetrated very hard quartz, the highest cost for a hole drilled with borts was $0.8338 per foot. This hole was drilled in the footwall of the Burra Burra mine to a depth of 52 feet, 37 feet being in hard silicious vein material and 15 feet in country rock; 2 57/64 k. of $15 borts were consumed in boring it.

The lowest cost per foot was $0.0321, and was obtained from a horizontal hole bored to a depth of 190 feet in the hanging-wall of the Burra Burra mine. This hole penetrated 10 feet of vein material at its mouth, and the remainder cut through soft mica schist so thinly foliated that there were but few pieces of core recovered more than ½ inch thick. The stone consumption was only 39/64 k. of $10 borts.

COST USING CARBONS

The highest cost of a hole drilled with

ANALYSIS OF STONE CONSUMPTION

Feet Drilled			Stones Consumed	Cost per Carat	Total Cost	Consumed per Foot	Cost per Foot
Total	Vein	Country					
1437	411	1026	25 39/64 k.	Borts at $10	$258.60	1.151/64 k.	$0.18
546	65	481	16 27/64 k.	Borts, 7 15/64 @ $10 Borts, 9 1/4 @ $15	72.03 135.94	1.304/64 k.	0.3809
798	226	572	14 23/64 k.	Borts at $15	220.55	1.179/64 k.	0.2764
167	90	77	8 3/64 k.	Borts, 6 1/4 @ $15 Carbons, 1 59/64 @ $85	99.84 154.06	3.246/64 k.	0.9225
840	228	612	5 3/64 k.	Carbons at $85	427.66	0.383/64 k.	0.5090
3788	1020	2768	70 1/4 k.	Totals and averages	$1368.68	1.184/64 k.	$0.3613

[1] Mining and civil engineer, 63 Atkin Street, Asheville, N. C.

carbons was $1.155 per foot. This hole was drilled in the footwall of the London mine to a depth of 92 feet, and penetrated 22 feet of vein and 70 feet of country rock. The loss in stones was 1¼ k. at $85. The lowest cost with carbons was $0.0719 per foot, from a hole in the footwall of the London mine which penetrated 30 feet of vein, and 44 feet of country rock. The stone consumption for the hole was 1/10 k. at $85.

CORE USING BORTS

The stone consumption given in the table does not take into account the loss from scrap borts in the drilling. This loss was: 6 59/64 k. at $15, $73.30; 5 57/64 k. at $50, $58.90; total 10 51/64 k., $132.49. The above amount distributed to the 2,948 feet drilled wholly and in part with borts gives an additional cost of about 4½c. per foot for holes drilled with these stones. There was no loss in carbon scrap, this loss occurring usually when the stones have been too small to be utilized in a bit.

Summarizing, and leaving out of the calculations those holes where both borts and carbons were used, the costs with borts were for 2,781 feet drilled, $687.12, or the cost per foot, $0.247. The additional loss for scrap, which amounted to $0.045 per foot, brings the cost up to $0.292 per foot. This is considerably less than the carbon cost of $0.5090, given in the table.

ADAPTABILITY OF EACH STONE

Borts may be profitably used in drilling soft ground, but in hard material they are useless, as the stones, all of which contain flaws, will shatter when encountering hard rock. It is doubtful if borts could have been used with cheaper results in drilling the 840 feet that were drilled with carbons. Some of this ground they would not have cut without great waste. Where part carbon and part borts were used, the carbons were substituted for the borts when it was found that the borts would not stand the work.

In some formations, where there are strata or zones of varying degrees of hardness, bits set with carbons might alternately be used with those set with borts, but the bits could not very well be set in advance owing to the varying gage of the hole.—*Engineering and Mining Journal*

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unite low fuel consumption, attained by Corliss valve gear on both high and low pressure steam cylinders, with first class air efficiency, provided by two stage compression, and the economy in floor space, foundations and freight which results from tandem construction.

An automatic co-ordinating speed and pressure regulator, original in these machines, together with massive fly wheels, enables Sullivan tandem compressors to run with perfect smoothness under any proportion of the load.

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MINE AND QVARRY

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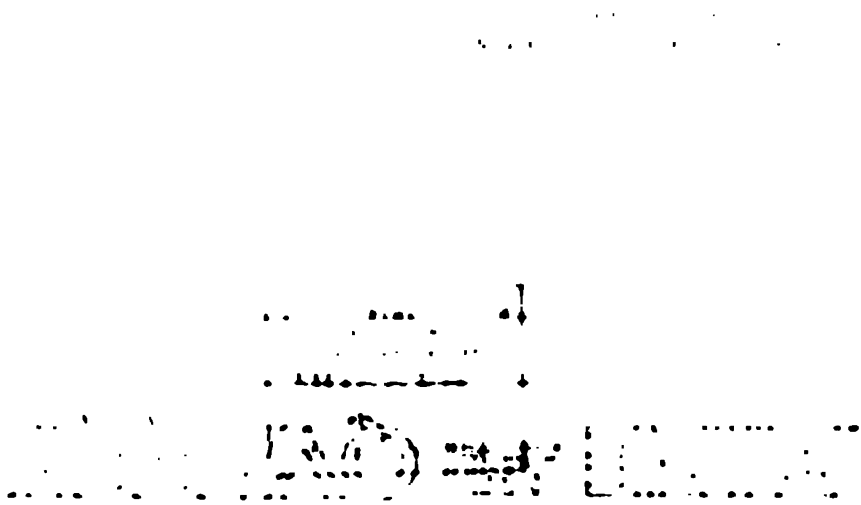


The mouth of the mine, Wind Rock Coal & Coke Co.

A TENNESSEE COAL MINE

By W. S. Hutchison[1]

The Wind Rock Coal & Coke Co.'s No. 1 mine is located at Wind Rock, Anderson County, Tenn., about four and one-half miles north of Oliver Springs. It lies in the southern edge of the Wartburg Basin, at an elevation of 2,400 feet above the sea level. This location commands a splendid outlook over the valley to the south. The camp can be reached from Khotan, on the Louisville and Nashville, or from Oliver Springs, on the Southern Railroad.

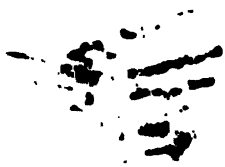
The mine was opened in the early part of 1904 by the Wind Rock Coal & Coke Co., composed of Knoxville parties. Development was delayed by encountering a split, composed of hard fireclay, which has since been exploited and found to be confined to 200 acres. The split is of a peculiar formation, being lenticular in shape, with its major axis approximately parallel to Walden's Ridge. The extent of the split was ascertained by driving a pair of entries through on the bottom bench of coal, and its maximum thickness was found to be 35 feet. Further exploiting was carried on by skirting the edge of the split and by outcrop prospecting. In 1905 the mine was purchased by the Bessemer Coal, Iron & Land Co., of Birmingham, Alabama, which now operates the property, consisting of 4,000 acres, as measured within the 30-foot crop line.

GEOLOGY

The seam of coal operated probably belongs to the lower Kanawha measures and is known as the Dean Seam. It lies high in the mountains and extends throughout the Wartburg Basin, having extensive workable areas in Campbell, Anderson, Morgan and Scott counties in Tennessee, and also in Bell County, Kentucky.

The inclination of the seam is from one to two per cent to the northwest. The main entry of the mine runs in practically the same direction, necessitating a grade against the load. This is unavoidable,

[1] Knoxville, Tenn.



Sullivan machine half way through the sumping cut.

Sullivan machine crossing a room face under its own power.

Sullivan machine moving on power truck.

When a cleared butt entry is not to be had, the tram locomotive makes a flying switch of its empties to the main entry and switches itself onto a loaded butt-entry track. The empties are then delivered to the various rooms, as required, by the gathering motors, while the tram motor takes its load to the outside. When the grade permits, the tram motor comes in ahead of its empties, gathers its loads as it advances along the entry, and pushes them ahead, distributing the empties as it goes and then returning with the loads. These methods of course necessitate a large supply of mine cars, some 300 being in use.

Two and one-half per cent is the steepest grade against the loads on the face hauls. The butt entries are very undulating, with a maximum grade of 13½ per cent. This, however, is in favor of the load. Wrecks formerly were frequent on the butt entries, but this trouble has been partially eliminated by replacing the 20-pound rails, then used, by 35-pound and maintaining an excellent haulway.

On reaching the surface, the cars are hauled over the weighing scales to the tip house. Here the coal is dumped into ten-ton monitors, which run by gravity over a standard gauge inclined plane, 4,350 feet long, to the lower tip house, where the coal is again dumped into railroad cars and weighed for shipment. The monitors have a carrying capacity of ten tons each, and are run double or in tandem, i. e., each trip carries a net load of 20 tons to the lower tip house.

The total length of the incline is 4,350 feet, with a vertical difference in elevation between the top and bottom of 1,300 feet. The average grade of the incline is 32 per cent, the maximum being 54 per cent. The average time required to run a trip over the incline is three and one-half minutes.

The hoisting drums are set vertically in tandem, the front drum being eight feet in diameter and the rear drum, nine feet. The former has four grooves and the latter five. The drums are provided with differential groove rings and with 12 inches of brake surface on both sides of each drum. The drums are governed with a hand brake, operated by a man at the tip house. The rope used is 1¼ inch plow steel, "long lay."

VENTILATION

Ventilation is accomplished by means of the split system. There are eleven splits in use at the present time (see sketch on this page). For butt entries, which are almost 1,800 feet as the standard length of the butt panels, wooden overcasts are used. These overcasts are built of 6 x 8-inch framing, boarded on both sides with one-inch plank and tarred with clay. For permanent overcasts, quarried sandstone laid in Portland cement, is used.

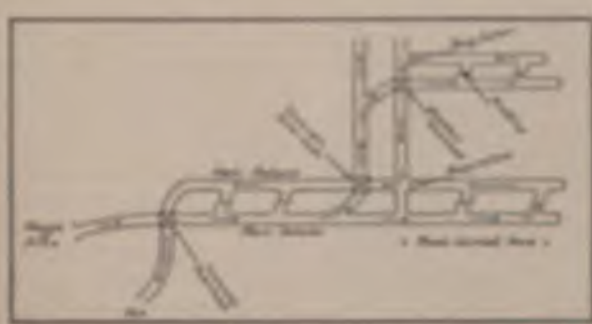
For brattices on butt entries, 6 x 8-inch timbering is employed, boarded on both sides with one-inch plank and filled with clay. On all face entries and main airways sandstone and Portland cement brattices are used, 18 inches thick, with a buttress on each side, having a base of 5½ to 4 feet. The buttresses are used for stiffening where the brattices are over 6 feet in height. The regulators are of ordinary wood brattices, with a slide door device which can be locked for any required opening.

Incline and upper tip house.

The fan is of the disk type, belt driven by an electric motor, and runs exhausting. It displaces 50,000 cubic feet of air running at 310 revolutions per minute against a ¾ inch water gauge.

SURFACE PLANT

The power house is located 250 feet from the pit opening. Direct current



Sketch of ventilation system, Wind Rock Mine.

at 250 volts, is furnished by two units, one a 150 K.W. engine generator, direct connected, for the machine load on the night shift; the other a 200 K.W. engine generator, direct connected, used for the day load.

A boiler room, equipped with two 150 H. P. high pressure, water tube boilers, adjoins the power house. Coal for the boilers is hoisted from the outside tram road level to the boiler room by means of a small steam hoist.

The water supply is obtained from three small mountain streams which empty into a reservoir, constructed in a convenient hollow in the mountain side. The retaining wall is 35 feet in height and has a fifteen-foot base, channeled two feet deep out of solid rock. The wall has a batter of 3½ inches to the foot, giving it a crest nearly five feet wide.

The reservoir pumping plant consists of a 5 x 8-inch, triplex, electrically driven pump, which raises water through a two-inch discharge line to a vertical height of 400 feet and empties into a 16,000 gallon tank. It is rain and surface water, well suited for boiler use and causing little or no corrosion or scale. It is interesting to note that the reservoir has been well stocked by the government with black bass, by way of furnishing diversion for the company men during a scarcity of orders.

A well equipped machine and blacksmith shop, motor barn, fan, oil and tip house and saw mill comprise the rest of the surface buildings and equipment.

The writer is indebted to Mr. C. H. Thompson, General Manager of the above company, for data used in the preparation of this article, and to Messrs. Doyle, mine foreman, and Scarborough, night foreman, for assistance in securing photographs.

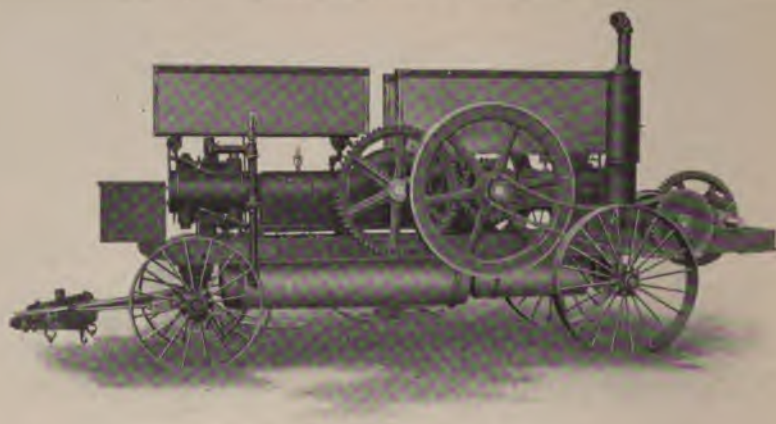
DIAMOND VERSUS "SHOT" DRILLS IN NOVA SCOTIA

The report of the Department of Mines of Nova Scotia for the twelve months ending September 30, 1909, has just been published. On page 179 and following, will be found the report of Hiram Donkin, Deputy Commissioner in charge of Government prospecting drills. The Government of Nova Scotia is the only user of drills, so far as available information shows, which employs both core drills of the shot or calyx type, and diamond drills in the same formation. The following table from the report, shows the comparative cost of drilling with the calyx and diamond drills:

	1908	1909
Cost a foot for all boring	$1.06	$1.405
Cost a foot for all boring by diamond drills	0.845	0.79
Cost a foot for all boring by calyx drills	1.34	2.166
Shot-cost a foot for all boring by calyx drills	0.056	0.055
Carbon-cost a foot for all boring by diamond drills	0.077	0.037"
Total boring for diamonddrills	3.378 feet	
Total boring for calyx drills	2,198 feet	
Average drilling per shift of ten hours, diamond drill	13 feet	
Average drilling per shift of ten hours, calyx drill	6 feet	
Cost of labor and management per foot, diamond drill	$0.58	
Cost of labor and management per foot, calyx drill	1.17	

From the above tables, it will be seen that in addition to the economy in carbon wear over shot wear, in using diamond drills, the economy of labor and management per foot, and in drilling speed is very noteworthy.

The formations encountered were the same in each case. Practically all of the drilling was done for coal, and the formations penetrated were principally shales, sandstones of moderate hardness, some limestone, and in one hole, bored with the diamond drill, the presence of conglomerate brought the cost above the average.



Sullivan portable gasoline driven air compressor.

or at any angle desired. When boulders project into the street, it is a simple matter to drill a hole and blow off the projection with a little powder.

In the intervals of street work, the outfit is frequently hauled to the city trap rock quarry, where it is used for excavating stone for the crusher, to be used later on the roads.

In some parts of the town, where trenches have been excavated for water mains, disintegrated granite of a very springy nature was encountered, similar to loose shale. Progress in this rock was particularly unsatisfactory with the steam drills, and in fact, pick and shovel has ordinarily been the method of excavation. The hammer drills were found very well adapted for this work, and on one occasion, nine holes, five feet deep have been drilled and the rock blown out, in three hours' work. This task would have required at least two days, if done by hand. Much of this ground was wet and in some cases the water stood an inch or more in depth over the rock. The rock was so well broken up by blasting, as to pass, with the exception of only a few pieces, through a one-inch ring. It was easily removed by shovel, and made excellent macadam for the streets. In ordinary trench work, the rock is broken into pieces from two to three feet in diameter and removed by means of a light wooden tripod, mounted across the trench.

Still another class of work is found in extension of the streets in the suburbs. In the thinly settled parts of the city, the fields are covered with the glacial deposits of boulders. By using hose in 50-foot lengths on the drills, these boulders can be drilled for a distance of 100 feet at each shift of the compressor.

THE AIR COMPRESSOR

The air compressor is a standard Sullivan WG–3 single stage machine, with air cylinder 8 x 10 inches, compressing 96 cubic feet of free air per minute at 165 revolutions to 80 to 100 pounds pressure. This is sufficient to operate three hammer drills, although only two, one large and one small are now in operation. The illustration on page 405 shows the outfit in use, and the illustration on this page, shows the other side of the outfit. The compressor is geared to a 15 H. P. gasoline engine, and both are mounted on a substantial steel truck with heavy broad-tired wheels. The entire outfit weighs about 8,000 pounds. As will be noted from the illustration, it includes a gasoline tank, cooling tanks of a special design for the engine and compressor, and

an air receiver attached beneath the frame of the truck for the compressor. The outfit carries a day's supply of gasoline and it is only necessary to add one bucket of water every other day to the cooling supply.

At the rear end of the outfit is a hoisting attachment, driven by gearing from the engine, which has been found very convenient in removing boulders and rock fragments from the sewer trenches, and from the line of streets.

HAMMER DRILLS

The hammer drills are of standard pattern, using hollow steel with hexagonal shanks, fitting a hexagonal bushing at the nose of the drill cylinder. A double grip handle is furnished, and the operator uses this handle to rotate the steel. When the operator pushes the handle against the cylinder, the throttle opens, and the drill operates until pressure is released, when it automatically stops running. By a special arrangement of ports, it is possible to turn any desired proportion of the exhaust air into the hollow steel, thus keeping the hole free from dust or sludge, under all conditions, and securing greater capacity and speed than would otherwise be possible.

The valve and piston motion in these tools is so arranged as to provide a cushioning effect on the back stroke, which reduces the vibration of the tool to a very low point, and does away with much of the jar and fatigue usually experienced with hammer drills.

The DB-18 tool employs one-inch steel, the starters having a gauge of 1¼ inches, and the five-foot finishing steel a gauge of 1⅛ inches. Seven-eighths-inch steel is used on the DB-15 drill, the starter being sharpened to 1¼ inch gauge, and the last or three-foot bit being 1⅛-inch gauge.

RECORDS OF WORK

Records kept on the classes of work described above show that the hammer drills are doing about three times as much work as the tripod drills formerly accomplished. The cost of operation for the drills and compressor is about one-third less than that of the steam drills and boilers. Some of the performance records of the hammer drills are worthy of note. In sixteen hours' time, the DB-15 drill put in 47 feet in 21 holes, ranging from 19 to 36 inches deep, and the DB-19 drilled 19 feet or five holes running from 32 to 60 inches in depth. This includes loading, shooting, and all details, and further, the drills were not operated at the same time. Holes five feet deep have been drilled frequently in 30 minutes, and the best time noted for a hole of this depth is 20 minutes. This drilling was done in very hard dark green bastard granite.

Thanks are due Mr. George E. Merchant, street commissioner, and Mr. Nicholas F. Sleep, Superintendent of Streets, for information furnished the writer in preparing this article.

A hammer drill excavating a sewer trench.

Another instance of the convenience of these portable air compressors and drill outfits is furnished by the Keystone State Construction Company of Yonkers, New York, which is building a reservoir for the Board of Water Supply of New York City.

The ground is heavily covered with boulders, which it is necessary to remove from the basin, and the contractors are breaking these up as removed, for use in concrete. Until recently, this work was done by hand at a cost of $1.50 per man per day. As each man is able to drill about five feet of block hole per day, this shows a cost of 30 cents a foot for drilling.

The contractor has recently installed a Sullivan portable compressor outfit of the size and type described in the above article, together with three Sullivan DB-15 hammer drills. These tools are drilling an average of 50 feet each per day. The cost of operation is estimated as follows:

3 drill operators at $3.50 per day	$10.50
Compressor attendant	3.50
Gasoline per day, 15 gallons at 20c.	3.00
Interest, renewals, wear and tear	6.00
Total cost per day	$23.00

$23.00 divided by 150 gives a cost of 15½ cents per foot of hole, which means a saving of 14½ cents per foot over hand work, or $21.75 per day. The saving at this rate will rapidly pay for the equipment and of course secures greater speed.

There are hundreds of places throughout the country where an outfit of this kind might be used to advantage, on account of its compactness, portability, and economy of operation.

It deserves the special attention of mining companies on account of its economy of fuel and power. In this respect, and by reason of its portability, it should prove a valuable rig for light development work in mining country difficult of access, and where water is scarce.—(Editor.)

COAL PROSPECTING IN CENTRAL QUEENSLAND

CORRESPONDENCE OF "MINE AND QUARRY"

The accompanying photographs show some phases of diamond core drilling work in a virgin country. They were taken on the Dawson River, in Central Queensland, where the contractors, the Goldfields Diamond Drilling Co., Ltd., were engaged, in the fall of 1909, in testing a new coal field for the Queensland Government.

In this particular section the tangle of tropical forest prevented the government geologist from taking observations, while the formation, a huge saddle back, had few outcrops to guide him.

It was therefore necessary to prospect the area with a diamond drill, before the geologist could chart it. The drill had to be transported to many places hard to reach, and to test every corner of the field, in search for complete information.

The country is cut up and criss-crossed with gullies, creeks and rivers, and roads and bridges are few and far between.

The photographs show how the transportation problem was solved. The drill (a Sullivan Class "C," capacity 1,500 feet), its equipment, boiler, and camp outfit, were carried across these waterways on an improvised aerial wire rope tramway. Some of the creeks and rivers rose in a few hours from 30 to 50 feet above normal level. When the rains became general, the country was flooded for miles, and moving a drill at these times with horses or bullocks was impossible. By the "spider web road," however, moves were made without much difficulty. During flood times care had to be exercised to keep adequate supplies of food and fuel on hand, as the regular

The only dry road.

Sullivan drill engines crossing rough country.

paths were impassable for weeks, even for a horseman, and the nearest railway station or store was 40 miles away.

The results of the drilling work proved highly satisfactory in supplying the required information. The double tube core barrel proved of value by securing practically a complete core from the exceedingly brittle coal found in this part of Queensland.

An interesting detail of this drilling was the use of a special device for recording the direction and angle of dip of the strata. While the core would ordinarily show the angle of the dip, it fails to show direction, which was a matter of great importance in the estimates of these coal measures.

This device pinces a due north mark on a piece of core, before it is broken from the bottom of the bore hole, and by an ingenious system of checks lands it on the surface without turning it from the position occupied in the formation, thus giving valuable aid to the geologist and mining engineer.

Sullivan Diamond Drills are used almost exclusively in all the Australian states. Twenty-five are owned and operated by the Goldfields Diamond Drilling Co. in its contract work.

A drill crew going to work.

One of the great ston

INDIANA OÖLITIC LIMESTONE

GEOLOGY, QUARRIES, METHODS

By George D. Hunter [1]

The Indiana oölitic limestone district extends from a point near Greencastle on the north, to the Ohio River, and ranges from two to 14 miles in width. The deposits are from 25 to 100 feet thick. The active quarries are confined to a comparatively small area called the oölitic belt, embracing Romona, in Owen County, Stinesville, Ellettsville, Bloomington, Clear Creek and Sanders, in Monroe County; Oölitic, Dark Hollow and Bedford, in Lawrence County, Salem, Washington County, and Corydon, Harrison County.

TOPOGRAPHY

The White River and its branches, Salt Creek, and numerous smaller streams, have worn what would otherwise be a plateau into gullies, ravines, and valleys, with an occasional gloomy hollow. The area is well wooded, except where, here and there, a bluff of limestone crops boldly out, or a knob of the original plateau shows at the summit of a hill. The quarries are usually opened on the slope of a hill, where natural drainage will carry off water.

Bloomington, one of the two headquarters points for oölitic stone, is a city of about 11,000 inhabitants. Here is located the Indiana State University, comprising a number of fine oölitic stone buildings. The town has several beautiful churches, also built of oölitic stone, and has recently erected a handsome Court House from oölitic stone quarried in Monroe County.

Bedford, the other leading city of the district, has a population of one more, or one less, than Bloomington (the writer refuses to say whether this refers to thousands or hundreds). Like Bloomington, Bedford has employed oölitic stone for numerous distinctive public buildings. Bedford is progressive. It owns more automobiles than Bloomington and takes more pride in its fine oölitic stone sidewalks, than Bloomington does in her paved streets (to be).

"Indiana oölitic limestone is one of the six great geological horizons which in that state comprise the lower carboniferous strata or Mississippian Period."

"The dip of these rocks over the region is from 50 to 60 feet to the mile, in a general southerly direction, making a larger area of stone accessible than if the structural position were more highly inclined.

[1] Bloomington, Indiana.

Several "Y" channelers on one track—a characteristic practice in the district.

Five Sullivan channelers on the second lift.

freestones, Indiana stone is nd much more readily worked nan after it is seasoned, because ns with age. Yet it never be- s hard or as difficult to cut as liceous rocks of equal strength, it ever become as hard as marble. : of grit is a saving on tools and ry. Besides, in the ease with olitic stone can be split diagonally ross the grain, it excels the building stone. These properties arrying from a massive solid bed e, when harder stone or one ifficult to work would be an "

any stone of such softness when , of such an even grain, so capable cut and carved almost with an jackknife, a stone which one com- hinks of as being unusually easy rt into lime and one which looks , could survive the severe fire ; upon it, is a matter hard for the to understand. These qualities ıould commend oölitic stone to itect no less forcefully than they the layman."

ELECTION OF QUARRY LAND

rst step towards opening up an :one quarry, before making any :lay of money, is to test the stone ı a core drill. Oölitic stone is so in formation, that several years' ance are necessary to grade it . To the experienced eye, the ıple shows many characteristics, ain, and hardness, or defects of kinds. Cores are taken out at laces and as deep as the stone s to be of good quality. The from the cores generally deter- e location of a new quarry open-

OPENING UP

a new opening is decided on, space is stripped and one or two rs put to work, cutting channels th of four, six, or eight feet, as indicated by the core to be good stone. A derrick is raised to lift out the blocks.

Conditions in opening a quarry are so variable that it will be best to assume a floor already established by nature. The first channel may be termed a wall cut. Then another channel parallel with the first is made, say six feet away.

Cross cuts are next channeled, perhaps 18 inches apart, usually for a distance equal to the width between the two first channels. Large steel "bull" wedges with flat feathers, are driven in the first cross channel, and the block of stone broken off at the bottom. Steel derrick dogs are then made fast to the broken block in "dog-holes" cut at the opposite ends of the block with a hand pick, and the block is lifted out. This block is called a "key-block" and is carefully examined for imperfections. Spalls are broken from the edges of the block with a spalling hammer, for further examination. If the result is favorable, the next block is removed in the same manner, and when enough of these smaller blocks are removed to give working room for a small steam drill, the distance between cross channels is increased, and horizontal holes $\frac{7}{8}$ inches in diameter are drilled seven inches deep and six inches apart at the foot of the block. The block is then split off by plug and feather wedges, and removed with the derrick. Key blocks channeled on four sides are difficult to lift, even after being freed on the bottom, on account of the fact that water and sludge in the cuts prevents air from getting beneath the stone, causing a vacuum. To prevent undue strain on the derrick, in such cases, a long pipe is attached to the steam or air hose and the sludge blown out from the cut, thus eliminating the suction or vacuum.

After the cross cuts have all been put down, long cuts are next channeled parallel to the first two cuts, and usually four feet two inches from the center of the first cut. This work continues until the whole floor is channeled.

A hydraulic stripper at work.

After the row of key blocks is removed cross channeling may be unnecessary. Oölitic stone as a rule has mud seams that run from east to west, and the long cuts should be at right angles to these mud seams, thus permitting the stone to separate at different lengths, 20, 30, 40 or more feet, which obviates cross cutting. These mud seams are generally from a few inches to several feet wide at the surface, but narrow as the stone is removed, until they become mere cracks in the stone.

FREEING THE BLOCKS

To remove the stone after it has been channeled into strips, it is first drilled by baby steam drills ("UA" Sullivan) along the bottom line of the channel, and plugs and feathers are used to break the stone. The stone is now turned over, to be broken up to the desired sizes (see page 418). Derrick "dog-holes" for hitches are made along the top of the channeled stone with hand picks. The hook ends of the dogs are placed carefully in the notches or holes, and one or more dogs are connected to a cable by loose sheaves with a clevis and pin to equalize the strain on all the fastenings. Power is then applied through the main fall cable, and with the assistance of bull-wedges, the large block of stone is freed and easily turned over. The floor on which it falls is bedded with small stones, which keep the block from breaking.

After the stone has been turned over it should be inspected by the quarry foreman, before any attempt is made to drill and break it to standard dimensions. When the stone is found free from defects, it is usually broken into large blocks, to be stacked; but for hurry orders, it will be broken to sizes to meet the order, lifted out of the quarry and at once loaded on a car for shipment.

ENLARGING THE QUARRY

This operation is repeated until the limit in depth of salable stone is reached,

Handling channelers outside derrick radius.

quarries differs in this regard from that in other building stone quarries. Overlying rock must be channeled, as blasting of this cap rock is seldom permissible. If there is to be any shooting or blasting for stripping purposes, only black powder should be used, and with great care, to avoid injury to the underlying oölitic stone.

POWERFUL MACHINES ESSENTIAL

Aside from the varying hardness of the overlying stone, the depth to be channeled also varies. If it were always possible to have a free or open end cut for the slush to run out of, the depth cut by the channeler would hardly require mention. But at times, particularly when starting a new quarry, the cut is closed, or has a blind end, affording no outlet for the slush. Channeling from 8 to 15 feet deep in blind cuts requires power to lift the long steels sufficiently to give blows of proper force. It is not the weight of the long steels alone that requires power, but in lifting the steels through the stiff slush, a vacuum or suction pulls against the engine, retarding the blow.

The power must be ample to lift the drills quickly and drive them through the slush onto the solid rock, with sufficient force to cut the rock economically.

The illustrations on page 412, and 418, show a feature, which, while perhaps not now peculiar to this district, at least had its origin here, viz., the operation of two or more channelers in gangs or batteries, on one long track. This practice secures a rate of cutting considerably higher than can be attained ordinarily by a single machine, since the action of the cutting bits of the battery tends to keep the slush at the bottom of the cut churned up, and prevents it from forming a cushion on top of the uncut stone.

Sullivan Y-8 channelers cutting 20 feet deep: this view shows a quarry block turned over and being split with drill and wedges.

Ten Sullivan channelers in a well developed quarry.

First Thought Camp, Orient, Washington.

THE FIRST THOUGHT MINE

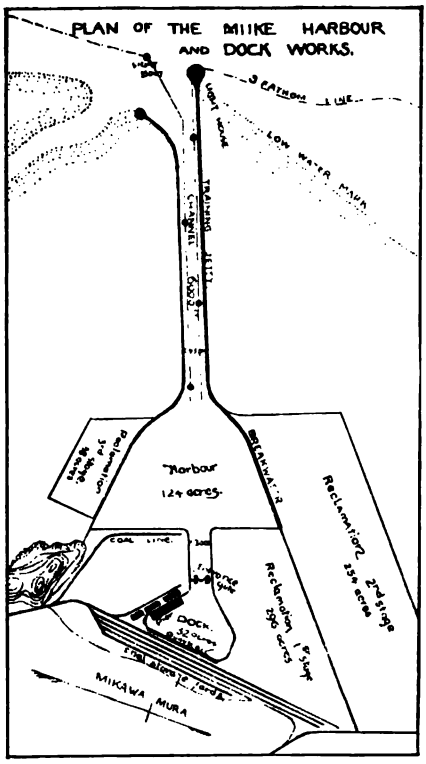
By C. W. Buckley[1]

The First Thought Mine is located about three miles from the town of Orient, Washington, and is owned principally by Canadian capitalists. The First Thought Gold Mines, Ltd., operates the mine. The amount of dividends has not been made public, as it is a close corporation, but the owners are satisfied with the mine's steady productiveness.

The ore bodies occur in an andesite formation. The dyke varies in width from five to 50 feet. A general view of this dyke is shown on page 421. The following is the present analysis of the ore: Gold, 1 oz.; seline, 1 oz.; silica, 60 per cent; sulphur, 3 per cent; iron, 8 per cent; lime, 10 per cent; alumina, 14 per cent; moisture, 3 per cent. The average gross value of the ore is $20 per ton. Treatment charges, including freight, average $6.00 per ton. It is impossible to distinguish ore of value from worthless rock without assaying.

Owing to the refractory nature of the ore, the smelters are able to handle only a limited quantity, which is used principally for converter linings. However, the mine has shipped at the rate of about 15,000 tons per year for the past five years. The lack of timber in sufficient quantity has led to the use of gasoline engines as prime movers at this plant. A 60-H. P. gasoline engine is used to drive by belt a 14 x 9 x 10-inch Sullivan two-stage class "W J" air compressor having a piston displacement of 338 cubic feet per minute against a pressure of from 80

[1] Spokane, Washington.



Plan of the Miike harbor works.

RECLAMATION OF THE SEA FRONT

The reclamation of the sea front is to be carried out in three stages, for the purpose of obtaining space for the storage yards, for railway sidings, for building a new town, and for various purposes connected with the development of shipping business. The area to be rec'aimed is as follows: in the first period, about 296 acres, in the second period, 254 acres, in the third period 38 acres.

THE WET DOCK

The wet dock is to be used principally for coal loading, and has a surface area of 32 acres at high water level. The depth within the dock is constantly kept not lower than 28 feet, by means of dock gates. Moreover, the front of the quay wall has a normal depth of 30 feet, which increases to 38 feet at high water line. It will be capable of accommodating eight or nine big vessels at the same time.

QUAY WALL

The quay wall is 1,380 feet in length, 41 feet, 6 inches in height, having a batter of one to 20 on the front side, and is constructed at the eastern extremity of the dock, for the simultaneous accommodation of three big vessels.

On the quay wall are to be instal'ed several sets of "Miike quick loading machinery," to provide a loading capacity of upwards of 10,000 tons of coal per day, about double the present output of the Miike coal mines.

THE DOCK GATES

The dock gates which control the water level in the dock, form the most important part of the works. The width of the passage is 66 feet, and at normal level, it has a depth of 28 feet on the sill in which the gates work. The gates, which have a weight of 90 tons each, are worked by means of hydraulic machinery.

IRON PIER

An iron pier, 300 feet long and 75 feet wide, is constructed along the southern side of the dock for the accommodation of vessels, which may bring general cargoes, such as raw cotton, foreign rice, bean cake, etc., on their inward trips.

INNER HARBOR

The inner harbor is that portion of the sea, bounded by breakwaters and sea walls as planned for the first stage of reclamation, and its total area covers about 124 acres. At the present time, a channel across the central part of the harbor and some anchorage space have been dredged out, but the deepening of the remaining section is to be undertaken in due course.

When the entire dredging is completed, the portion to the north of the channel will be set aside exclusively for public use.

Drilling trestle across the Chattahoochee.

SELECTING A DAM SITE WITH DIAMOND DRILLS

By H. L. Avery [1]

The Columbus Power Company is engaged in the construction of a dam across the Chattahoochee River, at a point about 15 miles north of Columbus, Georgia, just north of the Harris County line. This structure, which will be known as the Goat Rock Dam, will cost, together with the power house, $1,500,000, and will develop about 24,000 horse-power. This power will be used for mills and factories in Columbus and adjacent points. The dam will be 1,375 feet long, 75 feet high, and will contain 120,000 cubic yards of concrete. The power house will be situated at Goat Rock on the Alabama side of the stream, and is to be about 150 by 170 feet in area. The power generated by the water in its fall of 80 feet will be converted into electricity by hydraulic turbo-generators.

The Stone & Webster Engineering Corporation of Boston, the engineers of the undertaking, decided to ascertain the exact nature of the river bed and the formations below it, and for this purpose, engaged the services of the Sullivan Machinery Company of Chicago, to secure a set of diamond drill cores. The previous experience of the engineers with diamond drilling at the Hauser Lake and Wolf Creek dams, on the Missouri River, near Helena, Montana, had demonstrated the reliability of this method of testing.

[1] Resident Engineer, Stone & Webster Engineering Corporation, Columbus, Georgia.

The contractors began work in March, 1910. Their outfit consisted of two drills, a "Badger" and a "Beauty," removing a core seven-eighths of an inch in diameter, and two steam boilers on wheels, one for each drill.

At Goat Rock the Chattahoochee is broken by a sharp flight of rapids, and the water, while only four to nine feet deep, flows with great swiftness.

It was impossible, owing to the current, and to the likelihood of sudden changes in the water level, to support the drill and boiler on a scow, as was done in the Missouri River work.[2] After some study, a trestle was built out from the Georgia bank 1,100 feet to the Alabama shore. Poles of suitable size were cut in the woods along the shore, and set and braced in the manner shown on this page. Boulders were wheeled out on the structure as it advanced and dumped around the feet of the poles to give them stability.

Nine holes were bored from this trestle, to an average depth of 16 feet, in very hard, solid rock, chiefly hornblende. Eight other holes, making 17 in all, were bored from temporary stagings or landings, as shown on the next page. These were made just large enough to hold the drill, pump, and crew. Steam was run to the platform from the boiler

[2] See "Mine and Quarry" for September, 1909 —Ed.

Rock Drilling Efficiency

is measured by air consumption, plus wear and tear, plus labor, divided by the footage drilled.

If you will keep a record of these items from month to month, or year to year, you will find that your Sullivan Drills are drilling more feet, at lower cost per foot, that is, are more efficient, than any drills working under the same conditions.

Try it. If you have no Sullivan Drills on your work, let us send you one.

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MINE AND QVARRY

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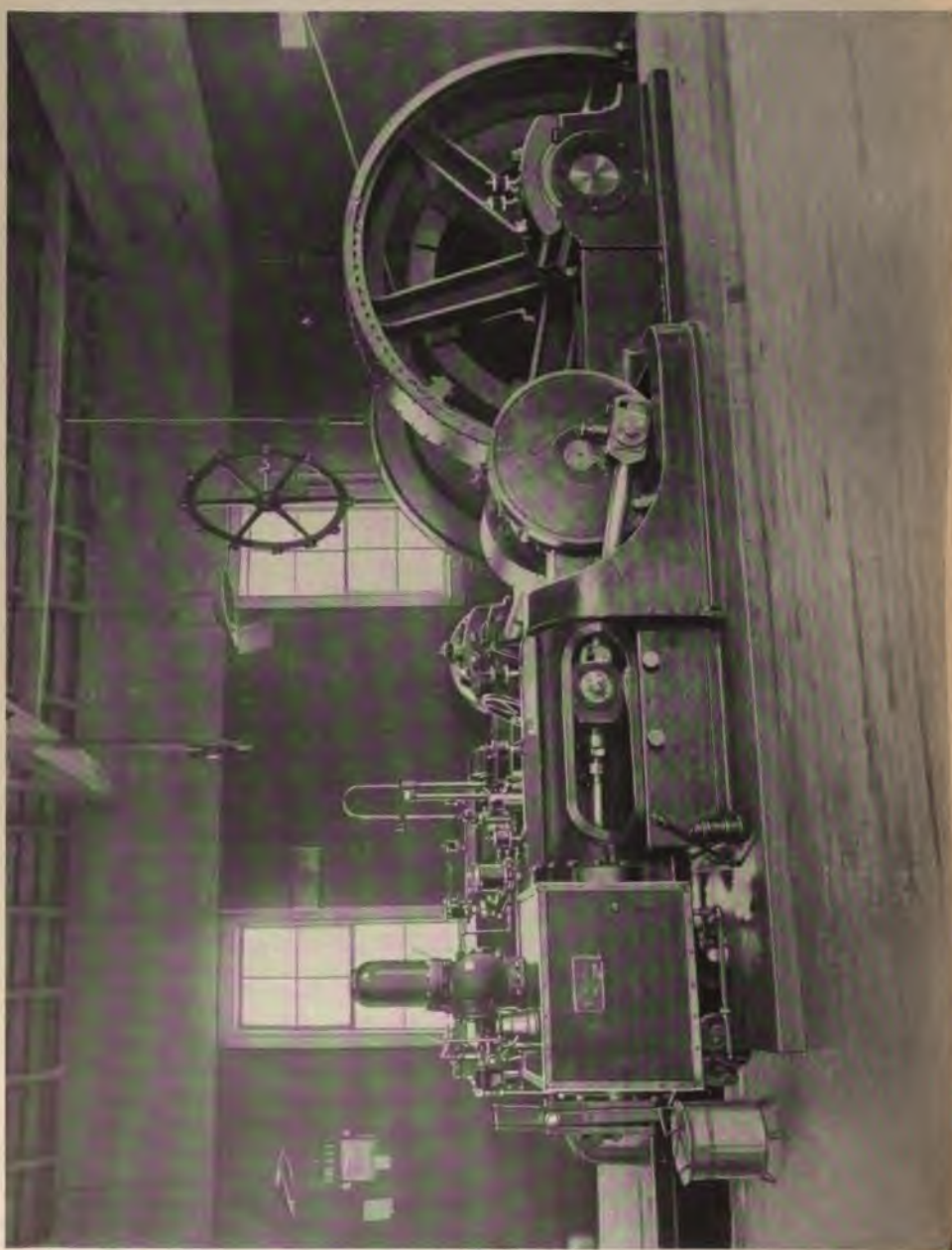


Head frame and mine buildings of the Buckeye Mine.

THE BUCKEYE MINE

MODERN METHODS ON THE MENOMINEE RANGE

By L. J. O'Gorman[1]

The development of the iron ore deposits on the Menominee Range in Upper Michigan is going forward rapidly. The older mines, many of which have been producing for a quarter of a century, give promise of continued production for years to come, while new explorations are taking their places at frequent intervals in the ranks of producing mines. On every hand the diamond drill is boring deep into the earth in search of more deposits. Thriving towns are springing up in the iron country. Many older towns that saw their rise and decay with the disappearance of the pine forests are beginning a new prosperity with recent discoveries of iron ore.

Part of the Menominee Range is in Wisconsin, due to the fact that the Menominee River, flowing through the range, forms the boundary line between the two states. The presence of iron in this section was determined in the early sixties, and mines have been shipping since 1877. In early times the Indians knew of these iron ore deposits, as Loon Lake was called by them Lake Komon, the Indian word meaning iron.

Systematic development work was begun by the Commonwealth Iron Company about 1877, and their mines, three or four in number, produced regularly until 1890. This early work consisted of test-pits, shaft sinking, and the old time hammer and drill mining. To-day the diamond drill, rock drill and modern power equipment enable this work to be done much more quickly and cheaply.

THE BUCKEYE MINE

After several years of drilling and exploratory work by the Commonwealth Iron Company, the Reserve Mining Company has recently developed its Buckeye mine, the output in 1909 being 50,000 tons. This year the output will be almost trebled and a large future production is assured.

The workings are about a mile and

[1] Iatyoming, Michigan.

Sullivan rock drill on tripod drilling in the Buckeye Mine.

one-half south of Commonwealth, Wisconsin, not far from some of the old workings of the pioneer company. The ore is a medium-hard red hematite, containing a good percentage of iron, and analysis shows it to be of an excellent grade for furnace work. It does not break too fine, being what is known as "lumpy," and therefore mixes well with the finer ores from the Menominee Range. A single compartment shaft is down 300 feet, and ore is being mined on three levels. During the coming winter, sinking will be continued to the fourth and fifth levels. The mine is comparatively dry, and pumping is a small item.

WORKING METHODS

The ore is mined by back-stoping. From the main level drift, raises are driven to a height of 15 feet and timbered for use as chutes. One raise is driven from level to level for ventilation. The ore is broken into the chutes, and the pile carried up almost to the level above. In this way about two-thirds of the ore can be stacked in the mine during the winter months. When the stopes are finished, the ground left between the levels is shot down into the chutes. The man-ways are carried up in the rock, and small drifts opened into the stope as the pile grows. This differs from some western practice with which the writer is familiar, in which square-set timbered man-ways are carried up at either end of the stopes, sets being added as the pile grows higher.

For breaking the ore, Sullivan "UC" (2¼ inch) rock drills are used exclusively, and the raises are put up with hammer drills of the same make. These latter drills are also used to good advantage for

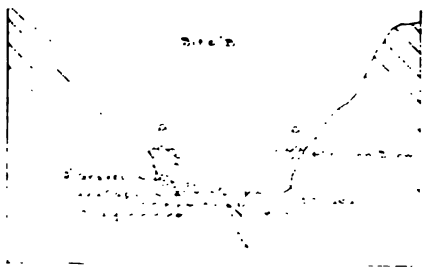
Sullivan stoping drill "block holing" a boulder in a chute.

breaking up boulders in the chutes. Instead of laying powder on the fragment to be broken, and thus risking damage to the chute, block holes are drilled as shown in the illustration. This also results in quite a saving of powder. When the shaft is continued from one level to another, a winze is sunk in the ore some distance from the shaft to the lower level. Then a drift is run to a point directly under the shaft, and it is then "raised" with hammer drills (as described in the April, 1910. MINE AND QUARRY). For sinking and heavy driving, Sullivan "UE 2" (3½-inch) drills are used.

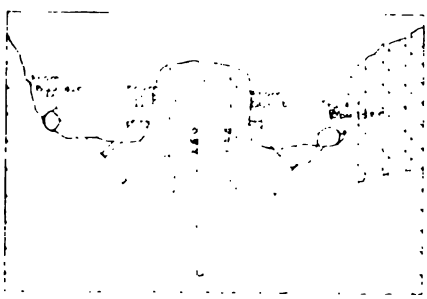
SURFACE PLANT

The ore is brought to the surface by a Sullivan automatic cut-off slide-valve hoist. This machine has 14 x 18 inch engines, and a drum 6 x 6 feet. It will handle a five-ton skip to a depth of 800 feet. At present a two-ton skip of the DeBeers type is used. The hoist is one of the very latest type, of which several are already in use in this field. It was especially designed for small or growing mines, and by means of the patented automatic cut off arrangement, a fuel economy is secured equal to that of a Corliss hoisting engine. In the engine house, together with the hoist, is a Sullivan "WC" tandem compound Corliss two-stage air compressor, having a capacity of 1380 feet of free air per minute. Power is furnished by two 150 H. P. return tubular boilers.

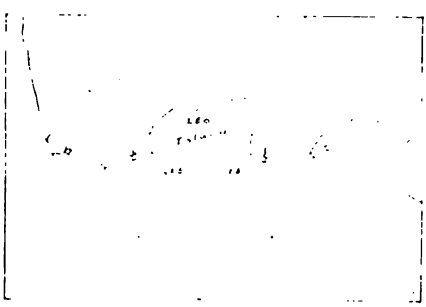
The surface equipment comprises sev-



Site B elevation.



Site "C" elevation.



Site C plan.

WORK AT "A" AND "B" SITES

It required but two holes to show that Site A was unsuitable. The formation was a decomposed volcanic ash, broken, soft and full of fissures.

The next work was done at Site B, a short distance below Site A. This proved to have some advantages as far as formation and foundation material were concerned. Disadvantages for plant location caused its abandonment, as it did not afford room for a spillway of sufficient length to keep up the required head during the low-water period, and would have necessitated the installation of flash boards at the low-water season and their removal during high water, to prevent raising the back water into the Casadero plant above.

Six holes were put in at Site B. The water was about five feet deep, flowing about six miles per hour. A scow was built, floated to position, wedged from below and loaded with rock so that it would rest solidly on the cribbing. An anchor rope was also used to hold the scow in position. Two of the holes crossed each other about mid-stream, approximately 50 feet below the surface, as shown in sketch B.

In some places the formation was so soft and broken that it was impossible to use the ordinary core barrel, because the water pressure alone would cause the broken particles to press down on the working face and grind up the core. The standard core barrel was replaced with a Sullivan special double tube core barrel, such as is regularly employed in coal prospecting. This held the core properly in place, and enabled from 60 to 90 per cent to be recovered.

SITE "C" WORK

At Site C, just below Site B, an island in the middle of the River forms a natural key for the dam. Holes were drilled in both channels, on both banks and vertically through the island, as shown in the sketches, on this page. The drills, boilers and other material had to be moved from the river bank to the island by rope tramways, as the sides of the island rose in sheer cliffs at all points.

At Site C, the water was six feet deep, running about 12 miles per hour. In the left channel two holes were drilled, one from cribbing over the water and one from a large boulder on which the drill was mounted. In both instances casing

Site C, where the diamond drills found good bottom. A drill is at work near the foot of the "pole" ladder.

Hauling a boiler to the island (Site C). The side skids keep the boiler from catching on the bridge supports.

was drilled into the hole and sealed in the hard rock. In the right-hand channel two holes were also put in, the drilling being done from cribbing and from a boulder. In this case, the boulder was penetrated, and the hard rock underlying then secured.

On the river bank open pits were dug to hard rock, and in certain places, churn drill holes were sunk to the lava cap, and diamond drilling then proceeded in the

"Badger" drill and crew on a land hole.

regular way. The drilling at Site "C" consisted of three vertical holes in the island; two holes in each channel of the river, and twenty-one holes on the river banks. These are shown in sketch C.

The moving of the drilling equipment to the island was very difficult, as all material and equipment had to be taken across on wire ropes. An extra boiler plant was necessary to supply water to the island for the drill boiler and for the drill.

SEALING POROUS GROUND

From the results of this drilling, Site C was chosen as one of the two locations for the new dams. The solidity of the rock was determined by drilling holes 35 to 50 feet deep, sealing the casing in the hole and putting 300 pounds water pressure on the hole. The porosity of the rock was then observed by the amount of water flowing into the hole. The holes were then drilled to a further depth of 70 or 80 feet and the water pressure again applied to note the increase in amount of flow. No increase of flow occurred below 40 feet in depth, indicating solid rock beyond that point.

Automatic mixing cylinders, coupled to an air compressor, will be connected to each hole and cement pumped in under 300 pounds pressure, thus filling up the interstices of the rock in both channels and preventing leakage below the dam.

SITE "D" DRILLING

When work at this location was completed, the drills were moved to Site D, about a mile and a half above the present Cazadero plant, and within a few feet of the back water from the present dam.

The surface gravel and over burden at Site D were washed off with a hydraulic giant, the stream being furnished by a four-stage centrifugal pump driven by a 200 H. P. motor, mounted on a scow in the river. A strip 50 feet wide was cleared off to the bed rock to a height of 150 feet on the bank. Two parallel rows of holes were put down, the holes being spaced 25 feet apart and the rows 40 feet apart, and staggered. Pressure determinations were made in each hole at 50 and 75 feet to ascertain the porosity of the rock.

A short piece of pipe is left sealed in the top of each hole and cement grout will be pumped into each hole under high

NEW SHAFT SINKING RECORD AT CORBIN, MONTANA

By Frank J. Tuck
(In Mining and Scientific Press, September 24, 1910)

H. E. Emerson, manager for the Boston & Corbin Copper & Silver Mining Co., has achieved an enviable record for rapid shaft sinking at the company's mine at Corbin, Montana. From June 15th to August 20th, a three-compartment shaft was sunk exactly 213 feet; from the 400 foot station to a point below the 600. In other words, about 100 feet per month was made, a record for the district. It is doubtful if a three-compartment shaft of equal size, and under similar conditions, has ever been sunk so rapidly and at the same time so cheaply. The actual total cost for power, labor, timber, and supplies was only $40.95 per foot, and this included a handsome profit check to the men who did the work on contract.

The rock through which the shaft was sunk was a dark hornblende granite, commonly known as Butte granite. The rock section of the shaft measured about 17 by 7 feet, each compartment being 4 by 4½ feet in the clear. For wall plates and end pieces 10 by 10-inch timbers were used, the dividers being 8 by 10. The sets were spaced 5 feet center to center. Only one compartment was employed for sinking; a second being used for hoisting rock from the two upper development levels; and the third as a pipe and ladderway. A double-drum electric geared hoist, of Wellman-Seaver-Morgan type, with a 100 horsepower Crocker-Wheeler motor handled the cages in both compartments very satisfactorily. A straight-sided sinking bucket of about 12 cubic feet capacity was hung to the cage in the sinking compartment, and was used for hoisting water as well as broken rock. The flow of water was not excessive, about thirty-five buckets per day being hoisted.

[Air for the drills was supplied by a Sullivan 400-foot "WB2" two-stage straight line air compressor — Ed.]

Two Sullivan "UB," 2½-inch machines, with air at 80 pounds pressure, were used, and from 18 to 25 holes were drilled per round. This included 6 cut-holes which were blasted previous to the others. The holes were from 5 to 7 feet deep, usually averaging about 6 feet. The firing was done by caps and waterproof fuse, and there was no trouble with the electric hoist when hoisting men before blasting. Forty per cent gelatine dynamite was used, and with a regular charge, the ordinary 10 by 10 blasting timbers afforded satisfactory protection to the lower sets. It is doubtful if this would have been the case if batteries had been used for firing. Station sets were put in at the 500 and 600-foot levels.

The contract for sinking the shaft was awarded to three miners who agreed to furnish their own supplies and do the drilling, blasting, shoveling, and timbering. Each of these miners took charge of an eight-hour shift and had three other shaft men working with him. Co-operation and hard work seem to have been the key-note of their success. No miners ever worked with more vim, intelligence, and enthusiasm. The timbering was perfect, the whole 213 feet being exactly plumb. While the men were paid $4 per day for their labor, their profit check netted them a snug sum, and there is no doubt that the company was given handsome returns.

The cost per foot of shaft was as follows:

Labor, cost per foot	$32.76
Lumber, per foot	4.58
Supplies, powder, caps, fuse, candles	2.04
Power	1.57
Total	$40.95

Besides the power and timber, the company furnished top-men, engineers, blacksmiths, and carpenters.

Smelting plant of the

Camp of Silverbell, Arizona

most satisfactory in every way. The upkeep cost of these drills is particularly low. There are about 120 "US" piston machines in use at the present time. All machines are operated by one man each, for both drifting and stoping.

All shafts were sunk with these 2¼-inch drills, and in the Enterprise incline, the most recent opening, two drills averaged 150 feet per month, carrying the shaft 6 x 8½ feet inside the timbers, In this case, and in all shaft sinking, three men were employed, two runners and a helper.

One man, using one "US" drill, will average 40 to 50 feet of hole per shift, putting in holes from four to six feet deep, and breaks 125 to 130 lineal feet per month in the ordinary size drift.

...r Co. at Bisbee, Arizona.

...ore behind the hill in the center.

Of the 800 tons of ore sent to the smelter daily, 500 tons are supplied from the Union, 250 tons from the Mammoth and the remaining 150 tons from the Billy shaft.

The ore from the Mammoth is transmitted from the mine ore bins a distance of 2000 feet, to the railroad ore bins, by compressed air locomotives. These locomotives are charged to 800 pounds pressure, the pressure being reduced to 140 pounds before entering the cylinders. One charge of the tank is sufficient to haul sixteen loaded cars, of three tons each, to the railroad bins, and to make the return trip.

The compressor for supplying air to the locomotive is of the three-stage

Sullivan "U S" rock drills in an Arizona stope.

straight line type, belt driven by a 40-horse-power motor which takes its current from a high tension power line coming from Sasco. This line also furnishes power for lighting purposes.

The writer is indebted to Mr. G. W. Diets, Auditor, Mr. Chas. Blethen, Master Mechanic, and Mr. David Morgan, Mine Superintendent, for many courtesies in the past, and at the time this article was written.

MARBLE QUARRYING IN ARIZONA

(Special Correspondence)

We believe that the knowledge of the existence of large and valuable marble deposits in Arizona will come as a surprise to many people; but, located in the Chiricahua Mountains in Cochise county, in the southeastern corner of the state, is one of the largest deposits of marble in the country. This deposit has been traced definitely over a distance of approximately 15 miles, and prospect workings made at various points over the deposit show the marble to be of a high grade throughout.

Active work is now being carried on by the Arizona Marble Company, a close corporation, composed of Denver capitalists, and under the active management of Mr. John G. Kerr, well known in marble circles. This company owns eleven claims, totalling 1760 acres, along the strike of the deposit, and has already opened them up to a considerable extent.

The Arizona Marble Co. has been in existence since January, 1909. The preliminary work necessary to actual quarrying operations has been completed. The deposit now being worked is 14 miles from Olga Station, the shipping point (eight miles from Bowie), on the Southern Pacific Railway, and the last

A corner in the Arizona Marble Co.'s quarry.

three miles of this distance are in the mountains. A splendid road for haulage has been built. A 110-horse power traction engine was used for hauling the machinery from the railway to the quarries, and now hauls the blocks from the quarry to the shipping point. The usual load from the quarry to the station is sixty tons. The traction engine has proved very satisfactory, but the intention is to ultimately install electric haulage, and the road through the mountains was laid out and constructed so that there should be but very little special work to do later, when electric haulage should be adopted.

POWER PLANT

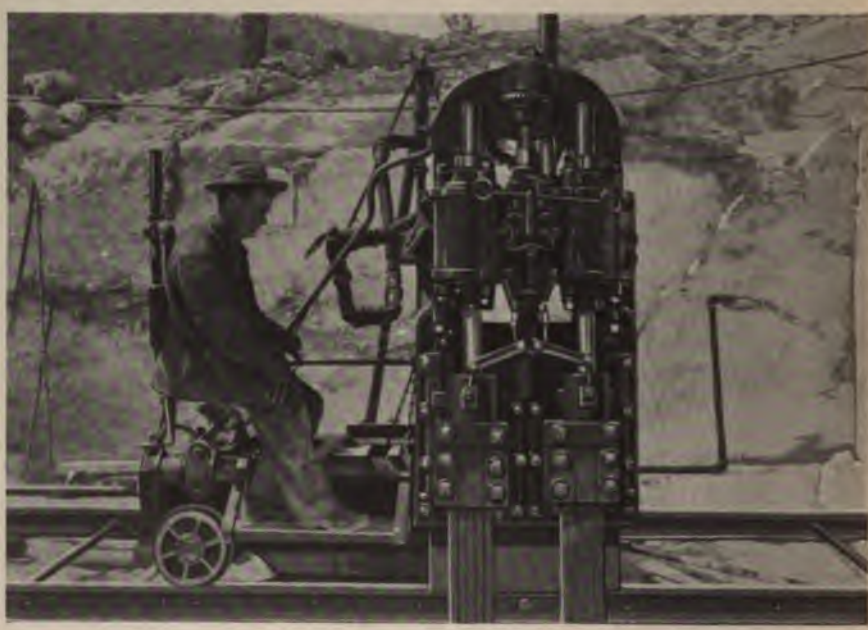
A great deal of thought and study was given to the power plant installation. Efficiency, economy of operation and dependability were the points most in mind. At present this consists of two 115 H. P. water tube boilers, supplying steam for driving the channelers and rock drills in the quarry, the derrick hoists, the Sullivan straight line Class "WA 2" compressor and the machinery in the experimental and testing mill.

The fuel used is wood, of which there is an abundance, cut from the company's own land.

QUARRY MACHINERY

Sullivan rock drills and channelers are used in the quarry operations; the latest addition to this portion of the equipment has been one of the new Sullivan duplex channelers, type "VW." A view of this machine in operation on the quarry floor is shown by the photograph (page 443.)

Compressed air is used for driving the Sullivan Class "DB-15" and "DB-29" hammer drills, used for "plug and feather" and "foot-hole" work. Very satisfactory results are being obtained in



Sullivan duplex channeler at Arizona marble quarry.

A fine panel of Arizona marble.

block-hole work for splitting up large blocks, by the use of the "DB-15" hammer tool. By its use, the time required in setting up a piston drill is saved, and no difficulty is observed in keeping the holes in line, in order that the blocks may split perfectly. In splitting large blocks, where holes to an average depth of four to five feet are necessary, the average drilling speed is 20 feet per hour. The air pressure maintained will average 100 pounds at the receiver.

The marble is strong and solid, and is quarried in very large blocks. An idea of the size of the blocks is given in the photograph of a corner of the storage yard, page 443.

Two derricks are in operation, one 30-ton and one 50-ton. To carry out the idea of centralizing the machinery as much as possible, the derrick hoists are located at the central plant, and one engine is used for driving both hoists.

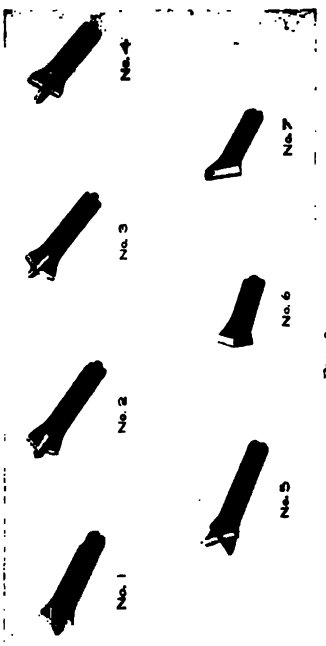


Fig. 3

Fig. 2

Fig. 1

particular kind of ground must be determined by experience, for a bit which proves its efficiency under certain conditions may be found inadequate in others, and a very slight change in its shape may bring about surprising results. For the foregoing reason it is impracticable to advance any hard and fast rule to follow in shaping stoping drill bits, but, as a general rule, the cross bit, illustrated by figure 1, sometimes modified to the X-shaped, as shown by figure 2, gives the best results, and such other modifications as the length and thickness of the wings, the angle of the cutting edge, the shape of the end, whether rounding, pointed or flat, may be determined only by experience in the particular kind of ground in which they are used.

The length of the wings is dependent to a great extent upon the hardness of the ground. If extremely hard, long wings are desirable, as they are capable of withstanding the blow much better than short, flaring ones; while on the other hand, short wings give the bit more clearance and enable the drill to be rotated easier for a given amount of reduction in the size of the gauge. On page 445 is a table, showing the results obtained by experiments on the seven different styles of bit shown in Fig. 3, which were operated under the same conditions, so far as consistent, in a moderately hard granite.

Under all conditions the faces or outside edges of the wings should be made flat, with square corners, and never rounding like a figure 8. This is necessary to maintain the gauge of the hole and greatly facilitates the removal of the steels if the hole is drilled at a flat angle.

Before starting, the proper steels needed to complete the hole should be picked out. It should be carefully determined just how much work each drill bit will do before the gauge begins to wear; and the operator should never try to use a bit the second time if the gauge is worn, even if it is sharp on the

RECENT DEVELOPMENTS IN THE UNDERCUTTING OF COAL BY MACHINERY[1]

EXTRACTS FROM AN ARTICLE BY EDWARD W. PARKER, WASHINGTON, D. C.

(Transactions of the American Institute of Mining Engineers, Canal Zone Meeting, November, 1910.)[2]

At the Seventy-sixth meeting of the Institute, held in New York, N. Y., February, 1899, I presented a paper on this subject entitled, Coal-Cutting Machinery, which has become somewhat out of date, in view of the decade's development in this feature of the coal-mining industry. It should be explained that the present paper is limited to the use of mining machines in bituminous mines. Practically all of the anthracite mined is "shot from the solid," no undercutting being done. Anthracite-mining is therefore not considered in the statistics or other references.

The statistical record as compiled by the United States Geological Survey shows that in 1898, the year preceding the presentation of my former paper, there were 32,413,144 short tons of coal undercut by the use of machines. In 1907 the machine-mined coal-product amounted to 138,547,823 short tons. In sympathy with the general decrease in coal-production during 1908, the output of machine-mined coal decreased to 123,183,334 short tons, but the proportion of machine-mined coal to the total output, nevertheless, showed an increase from 35.1 per cent in 1907 to 37 per cent in 1908. In 1898 only 19.5 per cent of the total product was undercut by the use of machines. The number of undercutting-machines in use in the bituminous mines of the United States has increased from 2,622 in 1898 to 11,144 in 1907, and to 11,569 in 1908. The total production of bituminous coal in the United States in 1908 was almost exactly double that of 1898, while the machine-mined portion of the product of 1908 was nearly four times that of 1898. These figures give an idea of the growth in the mechanical production of bituminous coal. It is unfortunate that we have no exact information in regard to the quantity of pick-mined coal produced. It is not sufficient to say that the difference between the total production and that reported as mined by machines represents the pick mined tonnage, since there would be included in this difference a much too large quantity of coal mined principally by the use of powder. And right here is one of the most serious problems with which the bituminous-coal operators of the United States are confronted at the present time. The undercutting of coal by hand with a pick is an exacting kind of labor and the miner may not be blamed for a disinclination to lie for 5 or 6 hours on his side making a cut of from 4 to 5 feet deep in the coal. When, however, conditions are such that the mechanical cutting of the coal is impossible, no other considerations should permit the miner to neglect his duty.

There has been in the bituminous regions a growing tendency to shoot the coal "from the solid," which consists of "making the powder do the work," a practice which cannot be too vigorously condemned. It is bad for many reasons, the least of which is the profligate waste arising from the excess of slack or fine coal produced, a product which is frequently unsalable, or, unless suitable for the manufacture of coke, must be sold at less than the cost of production. Moreover, it is pre-eminently anti-conservational. Far worse than this is the increase of the natural hazards to which the mining of coal is subject. To all familiar with bituminous-coal mining, it is well known that when "the powder does the work" the tendency to "windy" or "blown-out" shots is markedly increased and that these are

[1] Published by permission of the Director of the U. S. Geological Survey.

[2] Trans., xxix, 405 to 459 (1899).

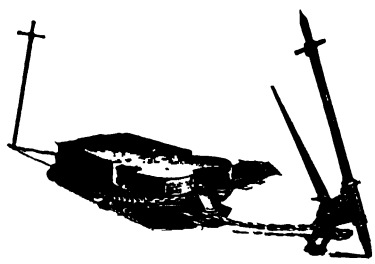
Sullivan pick machine.

dust-explosions which so often fill with horror the readers of the daily press. For of the reading public realizes, however, that a far larger aggregate of deaths in the coal-mines is due to the falls of slate and coal, and that these are indirectly due to the same originating cause. In 1907, the darkest year in the history of coal-mining in the United States, so far as the number of lives sacrificed goes, there were 947 men killed in gas and dust-explosions, with 343 injured while the falls of coal and roof killed 1,122 and injured 2,141. In 1908 explosions killed 396 and injured 328, and falls of coal and roof killed 1,080 and injured 2,701. The figures are significant, but it is hard to make the miner see that the weakening of the roof and the fracture of the ribs by the excessive use of powder in his work are responsible for the falls which make the long lists of casualties every year. Mining engineers know it, but it is a hard thing to prove it to the miner, or if he, too, knows it, he still assumes the risk. The public attention is not called to it in the same way that the horrors of explosions are heralded, for these accidents from falls, which usually occur singly, do not figure in the press-dispatches, and are not known outside of the community in which they occur.

A contributing factor, which has for one of its results the continuation and the extension of this reprehensible practise of shooting from the solid, is the custom in some coal-mining districts of paying for the mining of the coal on the mine-run basis. Where such custom obtains there is no incentive to the miner to produce a merchantable grade of coal. He is paid as much for slack as for good coal, and when "the powder does the work," what's the odds? In one state, Oklahoma, this pernicious influence has been so highly developed that by act of legislature the operators are compelled to pay for the mining of coal on the mine-run basis. Can any one imagine that the legislators of that state realize to what an extent they have made themselves responsible for the accidents that are sure to occur? And I am credibly informed that there is strong likelihood of no less a bituminous-coal producing state than Pennsylvania writing a similar law upon its statute-books. Of what use, may we well ask, to establish mine-rescue stations, unless to recover the dead bodies, if law-makers show such ignorance of the conditions which make toward the saving of life and limb, the protection of property, and the conservation of the coal. The coal-miner is one man who has to be protected not only against himself, but more particularly from the harmful activities of his would-be friends.

Let me give one illustration of the evil effects on the coal itself of paying the

Sullivan electric chain coal mining machine.



Sullivan air longwall machine.

miner on the basis of run-of-mine coal. One of the large operators in the interior region has furnished me a statement that shows some striking comparisons. The company operates in several states, and its production each year exceeds 1,000,000 tons. The mine-run basis was put into effect on May 30, 1900. The records kept by the company show that from 1894 to 1900 the proportion of slack was 27.8 per cent of the total output; from 1901 to 1905, with mining on the mine-run basis, the percentage of slack was 36, varying from 32 per cent. in 1901 to 38.15 per cent. in 1904. Since 1905 the company has made an agreement with the railroads by which the latter accept, as lump-coal, the mine-run product with 25 per cent. of slack screened out. This arrangement has apparently reduced the percentage of slack, but still, from June 1, 1905, to May 31, 1909, the screenings have equaled 32.36 per cent of the total production.

It is a self-evident proposition that the payment for this waste must eventually fall as well upon the miner as upon the operator and the consumer.

As the sewing-machine has supplanted "the bright little needle, the swift-flying needle, the needle directed by beauty and art," and the machine reaper has taken the place of the hand-swung cradle on the farm, so has the coal-mining machine ameliorated to a marked degree the labor-conditions in the coal-mines. A production by the use of undercutting-machinery of 138,500,000 tons, or 37 per cent. of the total output of bituminous coal, is significant. A portion, and probably a large portion, of this large quantity, had it not been undercut by machines, would certainly have been shot from the solid; and every ton of gain in machine-mined coal is that much more for better coal and greater safety for the mines and the mine-workers, notwithstanding the fact that the operation of the machines themselves is occasionally responsible for some of the casualties. The mine inspectors' reports contain statements of the men killed and injured by the mining-machines, but these do not and cannot subject to risk the hundreds of other employees, as is done every time a shot is fired from the solid.

While the anthracite mines of Pennsylvania are not liable to the same danger of dust-explosions as are the bituminous mines, the excessive use of powder by the miners, about 30 years ago, became a serious question, because of its effect upon the coal and upon the roof and pillars; and in order to minimize the evil, the operators, by agreement with the miners, increased the price of powder to a figure which made it an incentive for the miner to exercise economy in its use. The increase in the price of powder was compensated to the miner by an increase in wage. Nearly 25 years later, when the manner in which the adjustment had been made had passed out of memory, the "extortion" practiced by the operators became the subject of somewhat acrimonious discussion, and in order to settle the difficulty the practice was abandoned, whether wisely or unwisely I am not prepared to say.

In the mining of bituminous coal, proper regard for safety, and the securing of the maximum quantity of marketable coal, require that the minimum amount of powder necessary to bring down the coal should be used. This establishes as a pre-requisite that the coal should be

properly undercut and sheared. There are, of course, some mines in which the physical conditions militate against the introduction of mining machines, but these are comparatively rare.

A recent development in mechanical coal-cutting has been the design of a machine adapted to use in steeply dipping beds as well as those in which the inclination is slight. The machine is described in detail later in this paper. But whatever the physical conditions, the coal should be undercut, and no excuse for failure so to do should be accepted. At the present time the only mines in which the installation of mining machines is impracticable are those of comparatively small production, and of a capitalization and market-conditions which do not permit the necessary expense. These mines, however, are becoming fewer each year. The tendency in coal-mining, as in other lines of industry, is towards the large unit, for it is only in the operation of large units that effective economy in production and in the marketing of the product can be secured. The average production of the bituminous coal mines in the United States in which undercutting machines were employed, in 1908, was 94,177 short tons. Exclusive of the purely local banks, whose output in no case exceeded 1,000 short tons, the average production from mines in which machines were not used was 45,281 short tons, and including the output of local banks, this average is reduced to 29,442 short tons. It is claimed that many more machines would be used and that a much larger machine-

Sullivan post puncher for steep veins.

mined output would be mined but for the differential in wages made against the machine-mined coal. This, it is averred, takes from the operator the earning capacity of the capital invested in the installation, and limits the advantage secured by him to the larger proportion of lump coal obtained by having his coal undercut.

The two general types of undercutting machines most in use at the present time, as 10 years ago, are the pick, or puncher, and the chain-breast machine, although some long-wall machines are in use in the thinner beds, principally in the interior states. Long-wall mining is not practiced in the United States to the same extent as in Europe, nor to the extent it should be.

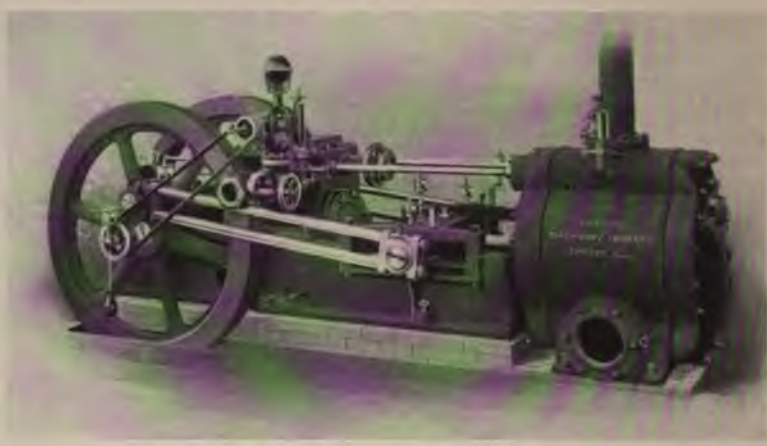
In 1908, of the 11,369 machines in use, 6,380 were of the pick, or puncher, type, 4,902 were of the chain-breast pattern, and 197 were long-wall.

ATOMIZING FUEL OIL WITH AIR

By R. E. Ellis[1]

Manufacturing industries in various parts of the country have long depended on natural gas for a cheap and convenient fuel. The supply of gas in some localities has fallen off materially in the past few years, and it has been necessary for the industries affected to change their furnaces and use coal, at a much higher cost, or to find some other fuel similar to gas in economy and application. Such a fuel is at hand in the shape of crude oil,

[1] Chicago, Illinois.



Sullivan "WA" air compressor, for low air pressures.

which has been produced recently in greatly increased quantities.

Oil has, of course been used as fuel for years, but as a substitute for natural gas, its application has lately received more than ordinary attention, resulting in many improvements in the methods of its use.

It has been the writer's privilege, during the past year, to observe some successful experiments along this line, and these notes have been prepared with the thought that the results obtained may be of interest to other engineers as well.

In order to burn oil under boilers, it must be injected under pressure as a spray or gas, the latter being considered to permit the most thorough combustion. Steam and air are both employed to atomize the oil, special burners being provided, with a double or annular nozzle, through which the oil and air or steam are simultaneously discharged.

A heater, placed on the oil supply pipe, raises the temperature of the oil to about 200 degrees Fahrenheit before it reaches the burner. Of the two atomizing media, air has proved to be much more satisfactory and more economical than steam. It saves fuel, because it is constantly dry, whereas steam is frequently damp, or even carries with it water of condensation. It is also possible to maintain an even pressure and temperature with air, both of which are difficult when steam is employed.

Opinions vary as to the pressure at which the air should be used. Some engineers consider from one to four pounds per square inch sufficient, while another and perhaps larger class prefer 15 to 25 pounds at the regulating valve. Of the two, the higher pressure seems to have much in its favor. Regulation of pressure is easier, and the temperature may be held more uniform. With low pressures, a very narrow margin of variation is allowable, or in other words, a slight variation in initial pressure has a greater influence on the operation of the burners than when heavier pressure is available.

It has been demonstrated that the greater first cost and additional horse power entailed by the high pressure installation, are more than compensated by the increase in efficiency.

One of the principal districts in which the use of oil has replaced that of natural gas is Eastern Kansas and northwestern

Oklahoma. The zinc and lead smelting furnaces, and the cement and terra cotta mills in this field form a group of industries requiring cheap fuel in large quantities.

A compressor used with success for this purpose in the Kansas field is the Sullivan class "WA" machine, arranged to give a pressure of 20 pounds to the square inch. These compressors are of the straight line pattern, with a simple steam cylinder 12 inches in diameter, a 19-inch air cylinder, and a common stroke of 14 inches. They are rated for a capacity of 600 cubic feet of free air per minute at sea level, at a speed of 150 R. P. M. The steam cylinder is fitted with balanced valves, controlled by Meyer cut off gear, while the air is admitted and discharged through automatic poppet valves of an improved type. Page 451 shows one of these compressors.

LOW PRESSURE SYSTEM

In the Kansas field, about 2½ barrels of fuel oil are assumed as equal to one ton of Kansas coal, or to put it in another way, one gallon of oil is equal to about 175 cubic feet of natural gas. Oil at 63 cents per barrel represents about the same expense for fuel as gas, if sold at 7 cents per 1,000 cubic feet.

CHICAGO REDUCTION COMPANY

The Chicago Reduction Company, which treats much of the garbage and refuse produced by the city of Chicago, has for some time past employed crude oil as fuel in its rotary driers, vaporizing the oil with steam. Its engineers found that the steam did not give uniform temperatures or pressures and was not economical, because a large amount of the heat produced was consumed in vaporizing the moisture in the steam. About nine months ago, after investigating the compressed air system, a Sullivan "WI" duplex belt driven air compressor was installed compressing 400 feet of free air per minute to 80 pounds pressure. This has improved the economy and efficiency of the service to a marked degree, accomplishing a saving in fuel over the steam vaporizing system of some 20 per cent. In other words, for every 1,000 gallons of oil needed with steam, but 800 are now

Sullivan "WI" duplex motor driven compressor, in plant of Chicago Reduction Co.

needed to do the same work. The air pressure is reduced at the burners to about 30 pounds per square inch. This relatively heavy pressure is required to secure the very high temperatures necessary to drive off all the moisture from the material sent through the driers. When steam was employed at the nozzles, a sediment like tar was given off from the oil, and deposited in a coating on the floors of the ovens, showing imperfect combustion. When the air system was installed, the heat generated was so much greater that the sediment was ignited.

The oil-air system is used in nine double-burner ovens, each seven by 11 feet, and each serving a rotary drier 70 inches in diameter by 40 feet long.

A larger Sullivan machine of the same type has just replaced the first unit. This has two air cylinders, each 16 x 14 inches, compressing 1,074 cubic feet per minute, at 165 R. P. M. to 40 pounds' pressure at the receiver. The cranks, crossheads, air valve eccentrics, and other main working parts are protected from dust by a tight iron casing and are oiled automatically by the bath system. The inlet air valves are of the semi-rotary pattern, positively driven, while the air is discharged through poppet valves which open and close automatically.

Power is purchased at a very low rate from the Sanitary District power station at Lockport, to operate an alternating current motor which drives the compressor by belt. An unloading valve on the air inlet pipe of the compressor permits economy of power at times when the demand for air is reduced. The use of compressed air for atomizing fuel oil is an application of considerable importance for this form of power.

A FACE LOADING MACHINE FOR COAL MINES

(CONTRIBUTED.)

The July number of MINE AND QUARRY contained a description of the mines and methods of the Wind Rock Coal and Coke Co. at Wind Rock, Tenn., in which occurred a reference to a coal loading machine for use at the working face. So much interest was manifested in this apparatus by readers, that the editors have secured and present below a brief description and a photograph of the loader in question.

The machine is essentially a shovel, delivering coal scooped from the floor into a conveyor at the rear, and thence into mine cars. The apparatus is mounted on a truck, runs on mine track, and is self-propelling. The various operations are performed by electricity, through sprocket chains, shafts and gearing, and are controlled by hand wheels.

The front part or jib of the machine, on which the shovel is mounted, swings laterally, as directed by the operator, covering a space 19 feet wide. The yoke supporting the shovel is provided with a vertical adjusting device, operated by a hand wheel, to adapt the shovel to the height of the track or to shovel over any irregularities in the bottom. The shovel can be raised to clear the track or lowered to shovel eight inches below the top of the rail. The shovel is 30 inches wide and handles lumps up to this size. The rear conveyor can be adjusted vertically and shifted laterally so that cars can be loaded readily on sharp curves or even on a track parallel to the loading track. This conveyor is a moving apron 24 inches wide and forms an excellent picking table to picks late before the coal goes into the car.

PERFORMANCE

Since the machine was used in the Wind Rock mine, a newer model has been con-

structed, which is now in use at the U. S. Coal and Oil Company's mine at Holden, W. Va. The coal at Holden is peculiarly hard and strong, difficult to shoot down and nearly as hard to shovel as large lumps of limestone. In spite of delays and lost time, for which the machine was not to blame, it averaged 128 tons per day; the lowest day's work (due to lack of shot coal) being 90 tons and the highest 150 tons. The average time of loading and shifting a car was 8.4 minutes, or 21.3 per hour.

The territory in which the machine worked consisted of seven rooms, recently turned off the airway in No. 5 mine, corresponding to the airway off the first right entry in No. 2 mine. Much of the work was done on curves. The rooms ranged in width from 21 feet to 27 feet and all but two had two tracks. The rooms were on the butts of the coal, which greatly increased the difficulty of shooting coal down.

The crew of the machine consisted of four men, as follows: One machine runner, one man in front, and two men to handle cars and pick slate.

During six days of its operation a record was kept of all features of the run, cars loaded, time required to load and shift, time to change the machine and time lost for any cause. During the six days the machine loaded 768 tons of coal, the time of loading and shifting cars being 36 hours, six minutes; time changing the machine four hours, 21 minutes; time lost 14 hours, 33 minutes; total time 55 hours. The machine loaded out four rooms per day and part of the lost time was due to the delay in getting coal shot and waiting on smoke. Much time was lost in pulling down standing shots.

We are indebted to Messrs. Myers & Whaley, engineers and builders of these machines, of Knoxville, Tenn., for the information and photograph used in this account.

The Hamilton Manufacturing Co. of Cleveland, Ohio, also build a loading machine intended for the same purpose.

Coal loading machine at work. The front shovel is rising to dump into the car basket, which in turn delivers it to the conveyor.

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"DA 15" Plug Drills

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MINE AND QVARRY

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CORRESPONDENCE

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MINE AND QUARRY

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The accompanying photograph shows four sections of a diamond drill core recently secured in drilling for limestone near Auburn, California, by the Mountain Quarries Co. The average length of the cores is nine feet four inches, and their diameter, 15/16 of an inch. They were removed with a Sullivan "Class H" diamond drill, using a ten foot core barrel. The cores, it will be noted, form a perfect record of the rock formation from which they were cut.

The Report of the Pennsylvania Department of Mines, for 1909, by James E. Roderick, its Chief, has just been published. It shows a total bituminous production of 136,205,695 tons, of which 56.03 per cent was mined by hand, and 43.97 per cent by machine. Since 1901, the percentage of the total product mined by machine has increased 7.77 per cent, but the total has increased nearly 60 per cent, so that the machine tonnage is much more impressive than it appears at first. The total number of machines used in the State in 1909 was 5,372, of which 1,929 were operated by electricity and 3,443 by compressed air.

The proportion of electric chain machines is gradually increasing, and the tonnage cut by them is greater than that cut by air machines or "Punchers." In 1909, 28,832,604 tons were mined by air driven machines, and 31,052,959 by electric chain types; or 21.17 per cent as against 22.80 per cent of the entire production of the state.

The State Department of Mines of West Virginia is taking drastic measures to put a stop to the practice of shooting from the solid. Twenty miners were arrested one day recently in the southern part of the state charged with this offense, and had to pay fines ranging from $10 to $17 each. A mine foreman who connived at the violation of the law was fined $50. —*Engineering and Mining Journal*, Nov. 26, 1910.

Diamond Drill Cores

Scotia pier and power plant

Ore chute to the pier

Tramway to the shipping pier

Entrance to submarine slope

Head buildings at the slope

MINING IRON UNDER THE SEA

Prepared for "Mine and Quarry" by H. W. Burns*

In Conception Bay, on the eastern coast of Newfoundland, lies Bell Island, the site of the Wabana Iron Mines, which during 1910 supplied 1,250,000 tons of ore to Canadian, European, and United States ports. It has now been established that the iron which outcrops on the Island is only the fringe of great deposits which extend far under the bay. A submarine shaft has been driven nearly 7,000 feet from high water mark by the Nova Scotia Steel and Coal Company, and has shown that the ore improves in quality and thickness as it gets deeper. It is largely because of the proximity of these deposits to the coal fields of Cape Breton that the steel industry of Eastern Canada has grown to its present proportions, and the ore reserves which have now been proved to exist under the ocean, insure the prosperity of that industry for centuries to come. It is only forty years since accident revealed the presence of the ore deposits, and not until 1850 was any attempt made to explore or develop them. Investigation was begun at that time by the Nova Scotia Steel and Coal Company, Limited, which resulted in the lease of the deposit and its eventual purchase.

The north side of Bell Island contains a number of seams of red hematite iron ore, running from 50 to 55 per cent in iron, three only of which are economically important at present. These seams or beds are interstratified with the sandstone and shales of the formation, with a common dip and strike, the former being about eight degrees.

EARLY DEVELOPMENT

The work of the Company, begun in 1895, at first was only open-cut mining, the earth covering being stripped and the ore then carried by an endless rope tramway to a pier on the south side of the island. This pier was a block set out some distance from the shore and connected with it by a suspension bridge; a trestle work was built to it later.

At first the ore was used solely to supply the blast furnace of the Nova Scotia Steel Company at Ferrona, but in 1899 the Dominion Iron and Steel Company commenced operations at Wabana. This company purchased from the Scotia the lowest of the three parallel beds of ore which the latter had been operating, together with all their equipment. The Scotia Company at once commenced to open up the middle, or Scotia, bed of ore in order to secure an uninterrupted supply. Twelve hundred men were kept at work that season, mining from the old property and developing the new, and when the time came for them to turn the Dominion property over, the Scotia bed was ready to produce all the ore required. Tramways had been constructed, a new pier built, and the Scotia went ahead producing ore without a break in deliveries.

The Dominion Company secured the upper and lower of the three beds of ore and a block of submarine areas adjoining the shore and containing about three square miles. The land ore beds of the two concerns overlap, one company work-

Newfoundland, showing location of Wabana

*Rockland, Maine.

Open cut mining in the lower bed

ing in some cases directly underneath the other, but in the submarine areas each company owns all the ore in its holdings.

When building their new pier, the Scotia Company took advantage of a great gulch near it to construct an immense storage pocket of ore. By very little work, this break was converted into a storage receptacle of much greater capacity than the one formerly used.

THE SCOTIA BED

For two years the Scotia bed was "stripped," but in 1902 two slopes were begun. Work was carried on rapidly, and within a year these mines had been opened up and were being worked by the room-and-pillar method. Both slopes were sunk at a considerable height above tide-water, and one was driven out on the shore above high-water mark, forming an adit. The slopes are carried from eight to ten feet in height, and 17 to 20 feet wide, in two sections, a 14-foot heading, and a side slice six feet wide. The sketch on page 457 indicates the method of drilling the holes in 8-foot ore. Another line of holes is put in when the ore is ten feet high. The center cut holes are about seven feet deep, and the rib holes six feet. All holes are bottomed with a diameter of 1⅝ inches, and 1½ inch 50 per cent dynamite is used for blasting.

The view of the drill at work underground, page 458, and the picture of open cut mining, shown above, indicate the marked vertical, or rhombohedral, cleavage of the deposit. This "blocky" ground causes trouble in drilling uppers, since the hole has a constant tendency to run out of line, requiring frequent changes in the position of the drill on the column. There is just enough moisture in the ore to make the cuttings ball up and pack behind the bit. The wet or down holes, however, are fairly easy to drill. Sullivan "UD" (3-inch) differential valve piston drills are used exclusively by the Scotia Company, and fifty are now in operation. The Dominion Iron and Steel Company employ forty Sullivan drills, including a few "UE2" (3⅛-inch") machines.

In the Scotia vein the drills are mounted on single screw columns without arms, but in the submarine slope and in the 14-foot bed of the Dominion Company, the double screw column with arm is preferred. Tripods are used in open cut work, and in driving raises or breakthroughs underground.

Air pressure for the drills is 80 pounds at the receivers, but at the ore faces is actually about 70 pounds, and in the submarine slope, now between 7,000 and 8,000 feet in length, the pressure falls to 60 pounds at the face.

BONUS SYSTEM

A runner of average ability puts in about 75 feet of holes per nine-hour shift with the "UD" drill. Good men have run up to 100 feet or more per shift. An interesting bonus system is employed by the Scotia Company, and since it was established, in 1904, the efficiency of the drilling work has been materially increased. An account of this system was furnished "*Engineering Contracting*" in 1906 by Mr. A. R. Chambers, and reprinted in MINE AND QUARRY for November of that year. The following is quoted to show the results of the scheme.

"Comparing the drill sheet for October, 1904, with that for August, 1905, we see that each drill averaged 58.6 feet per day in October, 1904, as compared with 69 feet in August, 1905. This is an increase of nearly 18 per cent, but, excellent as this increase is, it is not so striking as the increase in the number of tons of ore broken down by each drill. In October, 1904, each drill averaged 26.2 tons per day; while in August, 1905, each drill averaged 44.3 tons per day — an increase of nearly 70 per cent. We note also that this remarkable increase in output was not obtained at the expense of more dynamite; for, in the 1904 sheet only 0.64 tons of ore were broken per pound of dynamite, as compared with 1.2 tons per pound in 1905." With reference to the decreased amount of dynamite per ton of ore, Mr. Chambers says that this has been brought about by requiring the drillers to pay more attention to placing the holes as accurately as possible — to give the dynamite the best leverage; that is, cut holes to meet within about twenty inches, and not overburdening side-holes. "It is," he says, "also partly due to the fact that, whereas we used to run the drift eighteen feet wide, with twelve holes, we now run it about fifteen feet wide with twelve holes and side cut to eighteen feet wide with a couple of extra holes. The increased number of feet now drilled per day enables us to do this in the same time."

Plan of drill holes in room mining

The following notes on the drill work in 1909 may prove of interest:

No. 1 Mine

Drill days	2,458
Total feet drilled	331,521
Average feet drilled per day per drill	72.7
Output, tons (long)	140,804
Tons per foot drilled	.39
Tons per drill per day	42.3
Drill repairs	$347.66
Repairs per drill per day	.15
Repairs per foot drilled	.0021

No. 2 Mine

Drill days	4,739
Total feet drilled	323,317
Feet drilled per day	68.2
Output	267,023.6
Tons per foot drilled	.84
Tons per drill per day	43.6
Drill repairs	$903.66
Repairs per drill per day	.17
Repairs per foot drilled	.0024

Sullivan "UD" Drill in No. 2 Mine. Note the blocky nature of the ore

Before being sent underground, all drills are tested to determine the force of the blow, so that an efficiency rating can be assigned each machine. The testing machine is the invention of Mr. A. R. Chambers of the Scotia Company. It consists of a Sullivan "UD" (3-inch) drill, to the piston of which the piston of the drill under test is clamped. A system of pipes and gauges shows the relative efficiency of the new drill.

All drill steel is sharpened in a drill sharpening machine whose striking parts are made up of two Sullivan "UD" drills. This and the testing machine are located in the Company's very complete machine shop, near the No. 2 mine.

THE SUBMARINE SLOPE

About 1905 the possibilities of developing the submarine areas began to attract the attention of the Scotia Company. Further additions to its underwater holdings were secured, until it owned 35 square miles of submarine areas. At the same time the Dominion Company increased

its submarine holdings until it held five square miles. The Scotia Company decided to drive a pair of slopes to the submarine areas, and, an arrangement having been entered into with the Dominion Company by which the slopes were to be driven through the areas of the latter corporation, work was commenced in May, 1906. It was known that at distances of about 250 and 1,000 feet respectively, serious faults would be encountered, so it was not considered advisable to make any expenditure for plant until these should have been passed successfully. The following description of the first 4,000 feet of this slope is abstracted from a paper presented by Messrs. R. E. and A. R. Chambers before the Canadian Mining Institute, early in 1909.

"In August the first fault was encountered. Fortunately, although this dislocation amounted to an upthrow of 20 feet with only 85 feet of strata intervening between the workings and the bottom of the ocean, the volume of water encountered was trifling.

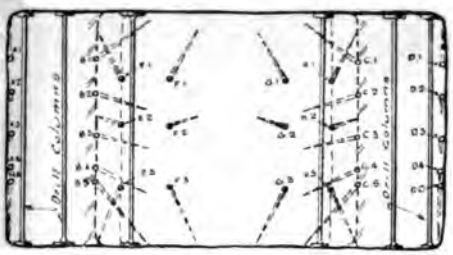
"From a study of the rock structure upon the land it was fairly evident that this upthrow would be followed by a corresponding downthrow running N.E. -S.W., after driving about 800 feet approximately at right angles to the fault first encountered. It was consequently decided to continue the slope in the strata underlying the ore in order to maintain as uniform a grade as possible. The wisdom of this course was verified by encountering the ore beyond the second fault at the distance and height expected, and of greater thickness. This fault was more serious, containing four feet of clayey decomposed rock, and an increased flow of water. The soft ground was handled by careful spiling and the water could easily be handled by two No. 6 Cameron pumps. The quantity did not exceed 50 gallons per minute.

"Beyond this second fault no serious difficulties were encountered for a further distance of 1,800 feet, at which point a downthrow fault of 26 feet was reached. The cover had increased to a total of 293 feet, and in consequence a greater feeling of security was felt in providing against any difficulties which might occur. With the increased depth, however, a corresponding increase in firmness was found and the clay encountered in previous faults was not met here. The slope was continued in the strata overlying the ore, but on an increased grade for a distance of 400 feet, when ore was again entered, having a normal thickness, and a normal dip of 12 per cent. The grade for the 400 feet was made 20 per cent., which by trimming will be subsequently reduced to 18 per cent. For this 400 feet the effects of the fault were noticed in the increased tenderness of the roof, necessitating timbers being placed skin to skin; and in the amount of water dripping from above. The total quantity of water was, however, in no way formidable.

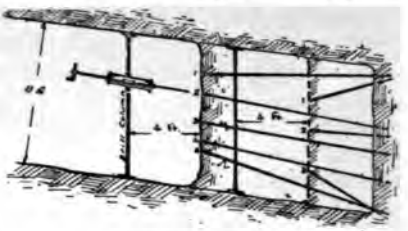
"On entering the Scotia areas at a distance of nearly 4,000 feet from the shore the conditions were as favorable as could have been hoped, and more so in that the quantity of water handled was very small compared with what was expected.

"The advances up to December, 1910, were as follows:

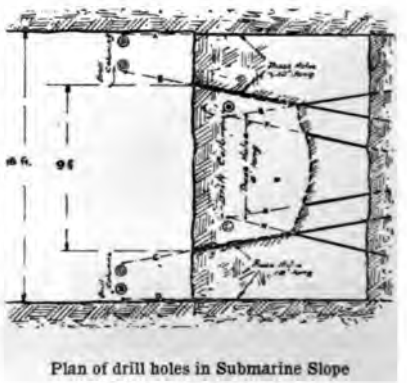
Slope commenced May 21, 1906	yards
Distance driven to Dec. 31, 1906	704.6
Distance driven to Dec. 30, 1907	1,916.1
Distance driven to Dec. 24, 1908	3,965.0
Distance driven to Dec. 30, 1909	5,400.4
Distance driven to Dec. 17, 1910	6,815.82
(at a depth of 1,300 feet below the surface of the ocean)	
The month of least advance was August, 1907, in passing first fault, or	42.3
The month of greatest advance was November, 1908, or	247.91
In the 4 weeks from the 16th of Nov. to the 14th of Dec., 1910, an advance was made of	270.1
In week ending January 23, 1909, an advance was made of	74



End Elevation



Side Elevation



Plan of drill holes in Submarine Slope

"This gives a record of 11¼ feet per day for a month. This gives a record of 12 feet 1 inch per day for a week. The size of excavation for this driving was 13 to 15 feet wide by eight feet high.

"As the work proceeded it was ascertained by diamond drilling that the lower bed had increased very greatly in both thickness and richness. At the outcrop, this seam was about eleven feet thick, but it increased gradually, and after passing the faults had more than doubled, while analysis of the one showed that the iron content was much higher and the silicon correspondingly lower."

METHOD OF WORKING

Three eight hour shifts are worked. When the air is cleared of smoke from the last shot, the drillers and loaders proceed to the face. The drillers and their helpers assemble the drills and columns, while the loaders throw back the ore from the face. The drills, of which there are two on this shift, are then set up four feet from the face, and about 20 inches from the rib or side, and each driller puts in five 12-foot center cut holes, B-1, 2, 3, 4, 5, and C-1, 2, 3, 4, 5, respectively (see sketch above) completing the round in about six hours. The holes are blown out with compressed air, when the shift is completed. After having cleared away the face for the drillers, the six loaders clear off the track, run in a trip of three cars and load up the ore thrown up the slope by the previous blast, which sometimes is 100 feet from the face. When the ore is reduced to a heap behind the drillers, one car only is used, and the loaders relieve each other, car about, three at a time. The loaders generally finish at the same time as the drillers and forty to fifty tons is an average shift's work.

The blasters then load the holes drilled with seven pounds of 50 per cent dynamite in each, tamping them securely with paper cartridges of clay prepared for the purpose. After the wires and blasting machinery are tested for strength and circuit the round is fired. If the work has been done correctly, the center cut will be taken out as shown in the sketch, and the ore thrown well up the slope. Owing to the heavy burden on these holes they will be only about half shot out. A little high pressure air is turned on at the face immediately after the blast, and the exhaust fans speeded up. In the course of a short while the air at the face

is quite clear, and while still a little warm, work can be resumed.

The next shift then begins, loaders clearing face as before. The regular drillers now set their bars four feet back from the face and as close to the rib as possible, and drill holes A-1, 2, 3, 4, 5, and D-1, 2, 3, 4, 5, 12 feet deep. In addition to these, two spare drills are set up in the cut and drill holes E-1, 2, 3, and F-1, 2, 3, and G-1, 2, 3, H-1, 2, 3, respectively six feet deep. As the extra drills do not come on the same shift each time, there are two spare drillers on each shift who, when not at this work, repair and advance ventilating pipes, swinging Sampsons, etc., and other odd jobs.

The order of blasting is now more elaborate than on the previous shift, and on the care taken in this work greatly depends the advance to be gained.

They first load and fire holes F-1, 2, 3, and G-1, 2, 3, three pounds to a hole. Next they fire the old bottoms of holes B-1, 2, 3, 4, 5, and C-1, 2, 3, 4, 5, with three to five pounds each, according to necessity. The third round is E-1, 2, 3, and H-1, 2, 3, five pounds to a hole, and finally A-1, 2, 3, 4, 5 and D-1, 2, 3, 4, 5, are fired, five pounds to a hole. This makes a total of about 200 pounds of 50 per cent dynamite to an advance of 8½ to nine feet, according to the success of the work done.

The method of using short bars and setting up the drills on top of the ore heap was at first tried and practised for some considerable time, but it was found that while saving a good deal of time in handling the ore, in the long run it did not pay.

The storage, thawing and distribution of the explosives for both the mines and the submarine slope are carried on at a central station which comprises a small magazine, thawing house, with detached boiler room, and a shed for testing detonators, located at convenient distances apart.

The thawing is carried on in a small stone building brick lined and wood faced inside, with an air space between the brick and stone, and the building is provided with a large entry for the reception and disposal of the explosive. It is heated by the ordinary hot water system, but the radiators are closed in wooden boxes to prevent accidental contact with the explosives.

The various blasting crews, wiremen, thawers, magazine storekeeper, and detonator tester, are all under the supervision of an explosive inspector, who constantly inspects all operations connected with the use and disposal of all explosives, and who immediately reports to the underground manager any unusual occurrence, and if possible, the cause of the same.

THE PLANT

Sullivan "UD" rock drills are used in the slope. Compressed air at 80 pounds receiver pressure is supplied to the drills and pumps in both the slope and in the working mines by two cross compound steam two stage air compressors and one straight line compound steam and two stage compressor, having a total capacity of 7,200 cubic feet of free air per minute. This plant also drives small hoists underground, and the fan engines.

The ventilating plant consists of one four-foot and two three-foot Sturtevant fans. The four-foot fan is direct connected to a vertical air driven fan engine, and is located near the upper part of the slopes, just at the bottom of the present workings of the No. 2 Mine, of which the slopes are a continuation. This fan is placed in the air course, and is operated exhausting. The two three-foot fans are placed as described below.

The intention was to sink the slope by double entry. In practice, however, it was found that the tendency was to place chief importance upon the slope farther advanced, with the result that it finally exceeded the secondary or ventilating

slope by a distance of 2,900 feet. To provide for ventilating this long single slope, recourse was had to spiral riveted galvanized iron pipe, connected with two blowers, with a suitable by-pass connection, so that they could be used either as blowers or exhausters. One of these was placed at the upper end of the pipe and the other, reinforcing it, about 1,000 feet further down. The first pipe used was 15 inches inside diameter, and was found to be too small to give entirely satisfactory results. Below the lower fan 18-inch pipe was installed, which still continues to give a plentiful supply of air to the face of the slope. As the slope advances, new lengths of pipe are added. On account of the blasting, the pipe cannot be laid nearer than 150 feet of the face, but no inconvenience whatever is felt.

DAMS

To protect No. 2 mine from possible inundation, sites for mine dams were constructed at a point situated vertically below high-water mark. When approaching this point the face was narrowed to six feet and then gradually widened again forming a "V." No reduction was made in the height. The sides, top, and bottom were lined with concrete. A small pipe was placed in the roof as an outlet for air when the pressure should come on the lower side of the dam, and capacious air and water pipes were built into the floor. Timbers to fill the opening were made of 10 x 10 pine, tapering to 6 x 6 and piled at the mouth of the slope in the same position they would occupy in the dam and carefully protected from the weather.

PIPING

The air line is eight inches in diameter as far as the workings in No. 2 mine and to the large Jeanesville pump, and five inches for the rest of the submarine slope. The water discharging line is six inches, being double from the large pump to the surface.

TESTING AIR PIPES

The air pipes are periodically tested as follows: All pipe ends are carefully closed as near to the drills as possible, and a pressure gauge is connected to the section to be tested. The section is then filled from the mains, and the supply valve closed. The air in the line is then released until the gauge reads 50 pounds, The time is taken and the pressure allowed to drop by leakage until it reaches 40 pounds, when the time is again taken. The loss in cubic feet of free air will be approximately half the volume of the pipe tested. This divided by the time will give the loss per minute. As the amount of pipe in each section is not often changed this information is readily available. The conditions, with the exception of the time, will be practically constant. The pipe fitter is thus constantly familiar with the condition of his pipes. Corrections for temperature would be necessary for accurate results, but in practice are not needed.

CARS

The cars used are of steel, of 30 cubic feet capacity, holding from 1.7 to 1.8 tons of ore.

TRACKS

The tracks are of 28-pound rails, except near the face, where an 18-pound rail is temporarily used. The gauge is two feet.

TELEPHONE SYSTEM

Telephones are installed in the slopes, connecting through a central office with all parts of the works, the office, and the houses of the manager and underground manager.

Efficient and modern electric pumps, fans, hoists, and other devices have been installed and the equipment of these mines is considered to be unsurpassed.

The writer acknowledges with thanks many courtesies and much aid in preparing this article to Mr. A. R. Chambers, manager of the Nova Scotia Steel and Coal Co., and to Mr. L. H. Johnston, manager of publicity for the company.

A MODERN OFFICE BUILDING

To the uninitiated, the construction and equipment of a modern office building are an unfailing source of surprise. The architect of such a building must be a little of everything, from a mining engineer to a skilled accountant, a lawyer, and above all a diplomatist and an organizer. The variety of materials, trades, and departments of engineering, mechanics, and art represented to provide the conveniences and services necessary for carrying on business, and the skill with which these are embodied inside of four walls, are hardly short of marvelous.

One of the best recent examples of these elements is the Peoples Gas Building, now being completed in Chicago by the Peoples Gas Light and Coke Co. at the corner of Michigan Ave. and Adams Street. This building has a frontage of 190 feet on Michigan Ave. and 171 feet on Adams Street. It is 20 stories in height above the sidewalk and has two basements. The concrete and steel piers which support the building, run to a depth of 74 feet below the street level, while the roof is 270 feet above the sidewalk.

This structure forms a prominent and pleasing addition to the imposing façade facing Chicago's lake front. It is probably the largest and in many respects is the most completely appointed office building in Chicago. When finished it will accommodate in the neighborhood of 3,500 people. It contains 416,105 square feet of rentable floor space and is intended primarily to accommodate the Peoples Gas Light and Coke Co., whose old building on this corner was torn down to make way for the new structure.

The company's counting room covers practically all of the first floor and its various departments occupy four entire stories and parts of two others, all connected by an elaborate system of pneumatic tubes, telephones, etc., to permit rapid communication and to save time. The remainder of the 20 floors are available for outside tenants.

The building is of the modern steel cage construction and was erected in halves, the north section being partially completed before the south half was begun, in order to provide quarters for the Gas Company before their old building was torn down. Remarkable speed was attained in the steel construction of both sections. The building contains about 10,000 tons of steel girders and frames and is very thoroughly fire proofed throughout. More than 50 separate contractors and supply concerns re-

The Peoples Gas Building, Chicago

One of the Rockport Granite Quarries

operated in the construction and equipment of this building. A list of these concerns and of their contracts is impossible in the limits of this article.

It may be interesting to note that the plumbing system includes about 40 miles of piping, and 18 miles of piping are required to regulate the 1,200 thermostats which enable each tenant to adjust the temperature of his office to suit himself. The occupants are served by 17 elevators.

No expense has been spared to make this structure one of the most convenient and artistic in the country. For this purpose the resources of the entire world have been drawn upon for ideas and materials.

Sullivan Plug Drills

The distinguishing feature of the exterior is a colonnade of solid polished granite columns, 18 in number, which rise from the sidewalk to the third floor on both fronts of the building.

These columns are 26 feet in height or 30 feet, including the capitals and bases, and are four feet in diameter. Each column weighs about 32 tons and is said to represent a cost of $3,500. They were supplied by the Webb Granite and Construction Company and were quarried and turned by the Rockport Granite Company of Rockport, Mass., from their "Sea Green" quarry.

The blocks from which they were turned were removed by means of Sullivan rock drills and plug drills from a ledge 200 feet below the surface of the ground. They were handled first by sea and then by freight cars, built especially

Alabama Marble Co.'s quarry

for the purpose, and are the largest monolithic columns in the city of Chicago.

The Rockport Granite Company has an equipment of more than 50 Sullivan Plug Drills and a number of Sullivan Hook Drills at its various openings. The cut shows a number of these tools at work in one of the pits, removing blocks from which columns will be turned later. Air for the quarries and cutting sheds is supplied by a Sullivan corliss cross compound condensing two-stage air compressor of 1,600 cubic feet capacity. The People Gas building is finished or sheathed up to and including the third floor with pink granite from Milford, Mass., and above that terra cotta tile is employed, made to represent granite. An enormous quantity of marble is employed in this building, for the corridor floors, wainscots and fixtures. Alabama white marble, amounting to 115,000 square feet has been used for the wainscots on all floors except the first. This marble came from the quarries of the Alabama Marble Company, Sylacauga, Ala. A general view of this quarry is shown on this page. The stone is first quarried with Sullivan marble channelers, of which seven are in use. Below is shown a pile of blocks as they come from the quarry and on the next page is shown a view of the company's mill where gang saws cut the blocks into slabs which are later polished and cut to size for the wainscot panels.

On the main floor of the building Grecian marbles are employed altogether, with the

Quarry blocks of Alabama marble

exception of the handsome fluted columns of Alabama marble at the main entrance to the Gas Company's Offices. The floors of the corridors and toilet rooms throughout the building are Greek Pentelikon stone.

This building is one of four large office structures which have been erected on the lake front in the last six years. Its tenants include a wide variety of professional men, supply and equipment concerns, as well as business and financial houses. The Sullivan Machinery Company, for five years in the Railway Exchange Bldg., one block south, moved its general offices to the fourth floor of the Peoples Gas Bldg. in May, 1910, and now occupies commodious quarters, aggregating 4,000 square feet of floor space, facing the Art Institute and Grant Park.

The architects of the building are Messrs. D. H. Burnham & Co. We are indebted to the officials of the Gas Company and to members of the architects' staff for much of the above information.

The Marble Mill, Sylacauga, Ala.

CUTTING LOW COAL BY MACHINE IN PENNSYLVANIA

By Geo. M. Crawford*

The Central Pennsylvania coal fields contain numerous mines in which the seam is only from two to three feet in thickness. To mine this coal profitably is a serious problem, on account, first, of the large amount of dead work, such as lifting bottom or removing top in headings and air courses to give proper height for haulage and ventilation; second, because of the severe competition from West Virginia. In the latter field the coal is higher and labor cheaper, so that it devolves upon the thin seam operator to cut down his cost of production to the lowest possible point, in order to make a reasonable margin of profit.

These conditions have created a demand for a machine which will mine more rapidly and cheaply than is possible by hand labor, and enable the highest possible percentage of lump coal to be produced.

SHAWMUT MINING COMPANY

One of the concerns in the district referred to, which has felt the pressure of these conditions and has made a careful study of the situation, is the Shawmut Mining Company, with offices at St. Mary's. This concern operates nine mines in the southern part of Elk County, on the lines of the Pittsburg, Shawmut and Northern Railroad. Most of these work the lower Kittanning Seam, which ranges from two to four feet in thickness. At the No. 5 mine at Elbon, about 20 miles from St. Mary's, the average height of coal is two feet eight inches, and the problem of methods which would make operation profitable has been a hard one for the company to solve.

ELBON NO. 5 MINE, SYSTEM OF MINING

The Elbon Mine is worked on the double entry, room and pillar system; one entry is used as a haulage and manway, the other for an air course. These main entries are driven ten feet wide, with 50 foot centers, leaving a pillar 40 feet thick between them. The cross entries are run every 350 feet, and from these the rooms are turned. A 50-foot supporting pillar is left on each side of the cross entries. The rooms are driven 250 feet in depth, on 60-foot centers, that is, are 40 feet wide, leaving pillars 20 feet thick. All entries, room-necks, and break-throughs are ten feet wide, and entries and air courses are five feet high, top being removed to secure this additional head room. The roof is of slate, generally of good strength, which permits wide rooms to be driven. The coal is underlaid by fire clay. A track is laid up each side of the room, six to eight inches of the bottom being lifted by the miners to give height for cars. The coal is reasonably free from sulphur, except at the bottom of the seam, where it appears in streaks or bands, rendering undercutting slow and difficult at times.

MINING METHODS

Until about a year ago the coal in this mine was undercut by electric chain breast machines and by hand pick. At that time a Sullivan continuous cutting self-propelling chain machine was installed. The results obtained with this machine were so satisfactory as to decreased cost of mining and as to the percentage of lump coal produced, that the company has placed Sullivan machines of the same type in its other mines. These machines are known as the Class "CE6" and are especially arranged for mining in low coal. Practically all operations are performed by the machine under its own power, doing away with the difficulties and loss of time involved in moving a machine of this size and weight in a space less than three feet high.

*Pittsburg, Pa.

Sullivan Low Vein Continuous Coal Cutter making a rib cut, Elkon Mine No. 5

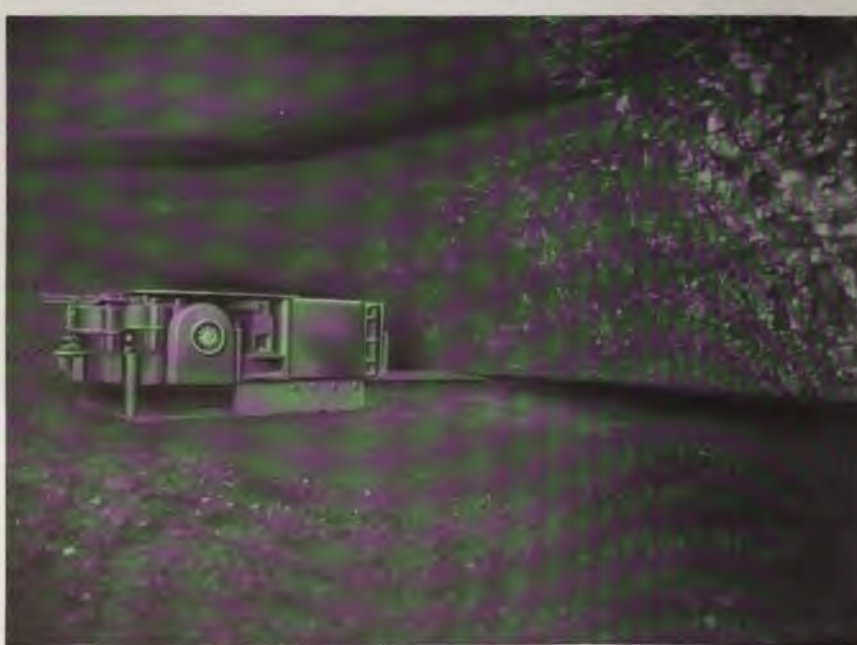
From another point of view, it is unnecessary to sacrifice strength in machines of this type in order to make them easier to lift or move about. The photographs on pages 468 and 470, taken in the Elbon Mine, show how the machine is used. It moves from place to place on a self-propelling electric truck, loading and unloading itself, without hand labor.

MINING MACHINES

The Sullivan "CE6" machine stands 31½ inches high above the rail, on its self-propelling truck. When mining, it travels on a flat steel shoe or plate and is but 21 inches high. It weighs 2,100 pounds, and the power truck 900 pounds, and develops 30 H. P. while cutting. This is about double the power of the ordinary chain breast machine. Instead of the triangular cutter bar with open frame, a straight bar 21 inches wide from pick point to pick point is used, and this is covered with a shield. When coal settles after being cut, these features enable the Sullivan machine to cut itself clear. The "CE6" works on the same principle as the high vein Sullivan room and pillar machine. After cumping at the rib it becomes virtually a long wall machine, traveling across the face of the coal under its own power, on a feed chain stretched between two jacks, one at each side of the room. The cutter bar remains under the coal until the other rib is reached and in this position the machine occupies only about five feet in front of the face, so that posts may be set permanently at that distance. This is a valuable element of safety in mines where the roof is weak. The ordinary breast machine must be backed out and barred over by hand after each cut or "board," and as the machine is from 11 to 14 feet long, this means considerable labor and not a little danger in tearing down and re-setting props. Another advantage of mining with "Continuous Cutters" is that the face may be brought closer to the face, and the work of the loaders made more rapid. The kerf or undercut is five inches high, enabling the coal to roll well forward when shot, and securing more lump and less slack on account of the smaller amount of powder needed to bring down the coal. The undercut is five feet and three inches deep. The photograph on page 472, taken in the No. 5 mine, after cutting and shooting, indicates the grade of coal produced by this means. The slack from the cutting is not dust, but near the size of nut coal.

The cutter chain and feeding mechanism of the Sullivan machine are operated through gearing, so controlled that the motor, which is of the horizontal, shunt-wound type, runs continuously, and the cutter chain or feed gears are thrown in or out of motion independently. The operator can manipulate the machine on the feed chain so as to throw the cutter bar forward or behind the body of the machine, to cut around obstacles, such as black jack or sulphur balls in the coal. Feed gears are available which will carry the machine along the face at from 10 to 20 inches per minute. In this mine, an 18 inch feed is employed, owing to the hard cutting mentioned above. The operator can vary the speed as required from a fraction of an inch per minute up to the full 18 inches. The feed gearing is protected by a friction clutch, set to slip when a certain draw-bar pull is exceeded. This relieves the machine of undue strain, when sulphur, bone, or other hard materials are met with, and reduces to a low factor the breakage threatened by such conditions.

This machine cuts a level floor and leaves no bottom coal to be raised before the next advance can be made. Gradual rolls are followed readily. In the Elbon No. 5 Mine coal is produced by the Sullivan machine for about one-half of the cost of mining with the breast type. To shoot the coal, as shown on page 472, a 1¼ x 6 inch cartridge is placed in the



Sullivan machine in Elbon Mine, above, at end of rib cut; below, crossing the face, right to left

center, for the tight shot, and a 1¼ x 8 inch cartridge is used on each rib.

HAULAGE

The mine track gauge is 20 inches; iron rails are laid in the entries and wood rails in the rooms. The mine cars hold 1,000 pounds each. They are handled by the loaders in the rooms, and are gathered at the room-necks by eight-ton electric locomotives, of which five are in use, and hauled in trips of 35 or 40 to the tipple. As the empties are hauled along the cross entries they are distributed to the loaders, and the loaded cars gathered and pushed ahead of the locomotive. When the last empty has been distributed, the locomotive has a clear track to haul the loads to the outside. The distance from the face to the tipple is now about two miles. A system of signal lights is installed along the entries for directing the motor-men.

VENTILATION

The mine is aired by an 18 foot ventilating fan, operating as a blower.

PRODUCTION AND LABOR

The No. 5 mine is now producing about 300 tons per day; about 125 miners are employed and live in company houses near the mine.

MANAGEMENT

Mr. Frank Sullivan Smith, of New York City, is President of the Shawmut Mining Company. Mr. Geo. S. Ramsay, of St. Marys, Pa., is general manager, and Mr. W. R. Craig, also of St. Mary's, is chief engineer; Mr. James Jones, superintendent of the Shawmut and Elben mines, and Mr. Jno. Murray, chief electrician, are both of Shawmut, Pa. Mr. Wm. Faulk, of Elben, is the mine foreman.

To Mr. Ramsay belongs much of the credit for the successful development and profitable operation of the company's properties. Beginning in 1906 as superintendent of three mines at Shawmut and Elben, he became general superintendent in 1909, and in 1910 general manager, with nine mines under his direction.

In addition to the mines of the Shawmut Mining Company, Mr. Ramsay also has under his management the Alleghany River Mining Co., which owns one of the above shipping mines, and now has under development five new mines from which it expects to produce 11,000 tons daily. These last named mines are located in Armstrong County, on the Pittsburg and Shawmut Railroad, which connects with the Pittsburg, Shawmut and Northern. Credit is due Mr. Ramsay for his ability and energy, in developing new mines and in increasing the output of the older openings.

The writer is indebted to Messrs. Craig and Jones for their courteous assistance in furnishing data for preparation of this article.

A loaded trip

DRIFTING WITH A STOPING DRILL

By H. E. Moon*

It is interesting to note the ingenuity displayed by some miners, especially those who are leasing, in keeping down operating and equipment costs.

An example of this recently came to the writer's attention in the Cripple Creek District of Colorado. Two miners had a lease on one of the lower levels of the Granite Mine. Their work was entirely stoping and raising and their drill equipment consisted of air feed stoping drills.

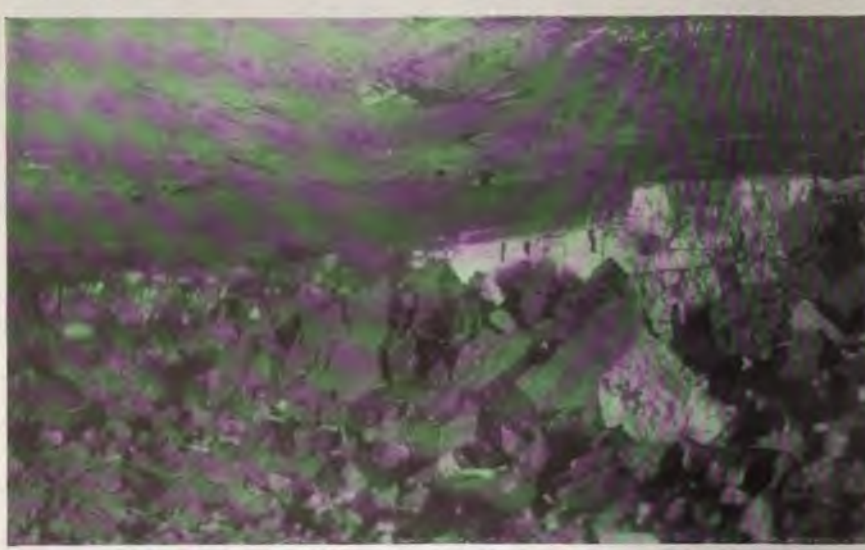
They drove the raises "A" and "B" Fig. 1. Owing to heat and bad air and also to assist in opening the stope, they decided to drive the drift "C" from "A" to "B," thus giving a chance for ventilation. They could not afford to purchase a drifting drill, but with the aid of a simple foot-plate they found that they could use a stoping drill to put in holes at all angles from the vertical to the horizontal. In one case they put in a hole five feet deep which dipped about four inches below the horizontal in that distance.

This foot-plate (Fig. 2) was made of a sheet of ⅜-inch steel, with ears turned down at the corners to act as spikes and hold the plate onto a plank. To this plate was riveted a piece of angle iron bent to a "U" shape.

The drill used for this work was the new Sullivan Class DA-21 stoper. The ground was a hard granite. The cutting speed was from 14 inches a minute, in vertical holes, to eight inches a minute in horizontal holes. A blow pipe was connected with the air supply and used to clean the cuttings from flat holes.

(Sullivan Stope Drills are in use in the anthracite coal fields of Pennsylvania for work like that described above, for driving short tunnel headings. In this instance, hand feed hammer drills are used to drill down holes in the face. The rock next the tunnel floor is then shot out, and the stoper used to drill upper holes.—Ed.)

*Denver, Colorado.



A room after shooting; note the large amount of lump coal

Fig. 1. Plan of raises and drift

Sullivan Stope Drill in a copper mine

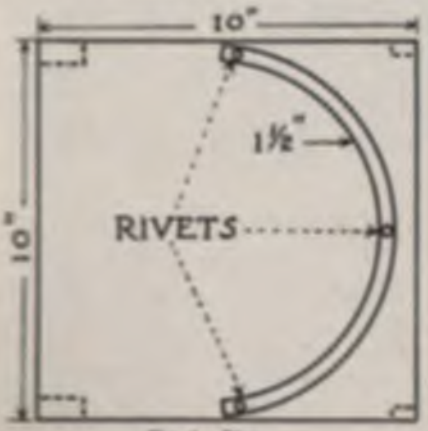


Fig. 2. Plan

Fig. 3. Foot plate for Stope Drill. Elevation

IMPROVEMENTS TO THE ST. MARY'S FALLS CANALS

R. J. Sharp*

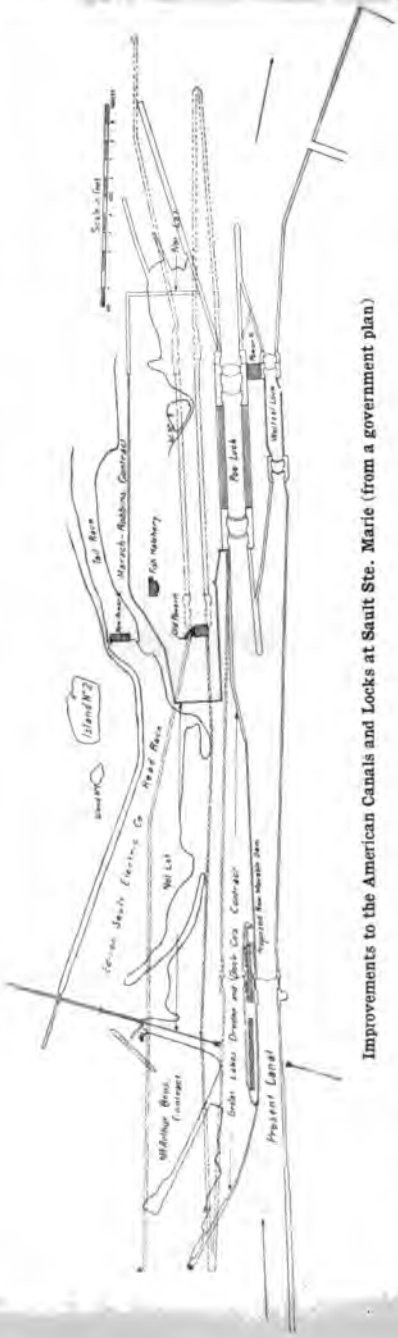
For several years the United States Government has been improving the facilities for handling vessel traffic at the Sault Ste. Marie. In 1897 the tonnage carried between Lake Superior and the lower lakes amounted to 19,000,000, while in 1909 it had risen to nearly 50,000,000 tons. Work carried on in the past three years has provided a double channel below the locks, 21 feet deep and each half 300 feet wide. The new West Neebish Channel, a rock-walled rock cut 8,500 feet long, was described in the June, 1908, Mines and Quarry.

*Duluth, Minn.

The locks themselves and their approaches are now receiving attention which has been badly needed for several years, on account of the increase in the size and draft of the vessels, as well as their number. These improvements consist, first, in widening the approach to the Poe and Weitzel locks to 200 feet throughout, and in constructing an entirely new canal and lock, north of the present channel.

CANAL WIDENING

The sketch on page 474 shows the work covered in widening the old canal. Previous to this improvement, delay was caused by the fact that at the interna-



Improvements to the American Canals and Locks at Sault Ste. Marie (from a government plan)

tional bridge, the channel was only 125 feet wide. The strip excavated is about 125 by 4,000 feet; work was begun in March, 1908, and completed before the opening of navigation in 1910, by the contractors, the Great Lakes Dredge and Dock Co., of Chicago.

The quantities of material to be excavated and the contract prices were as follows:

Dirt excavation and dredging, 135,000 cubic yards, at	$0.55
Rock excavation, 260,000 cubic yards, at	1.30
Rock channeling, 85,000 square feet, at	.30
Revetment wall timber, 150,000 cubic feet, at	.10
Filling above with stone, 20,000 cubic yards, at	.30
Concrete, 7,000 cubic yards, at	4.00
Special concrete, 9,500 cubic yards, at	5.00

The total depth of the excavation averaged 30 feet, of which from 7 to 9 was earth and the remainder rock, consisting principally of Potsdam sandstone. About 1,400 lineal feet of timber crib walls were built and 3,700 lineal feet of concrete walls.

Prior to letting the contract, the United States erected a coffer dam at the upper end of the work, which permitted the excavation to be carried on in the dry. To avoid interruption of traffic, a strip or rib of rock about 40 feet thick was left between the old canal and the new channel. This wall or rib was blasted out during the winter of 1909–1910, after the remainder of the excavation was completed, during the period that the canal was closed to navigation.

CHANNELING

The photograph on page 475. looking up stream from the locks on March 27th, shows this work very plainly. The old channel is at the left of the outer approach and the extension at the right. Both

Looking west from the Locks; widening the approach

the rib and the outside wall were cut by stone channeling machines before the material between them was excavated. This was done in order to avoid shattering the walls and weakening them, and also to secure a smooth and even finish to reduce friction of the flowing water and to prevent accident to vessels touching the walls. This would have required trimming or filling in after the excavation was completed, if the blasting had been carried up to the walls themselves.

The contractor's plant for this work included two Sullivan Class "Y8" channeling machines, each carrying its own boiler; and 12 standard Sullivan Class "UF11" 3½-inch rock drills. These were operated by air from a 1,200 foot Sullivan "W.J." two stage, self-oiling air compressor, driven by belt from a 150 K. W. synchronous motor, taking alternating current from the Soo Edison Co. at 4,000 volts.

The contractor's equipment also included two steam shovels, four dinky locomotives and a large number of dump cars. The conditions for drilling and channeling were exceedingly difficult. Much of the work had to be done during the winter, when snow, ice, and zero weather were the rule. The rock encountered consisted of ledges of varying hardness, interspersed with mud holes and pockets. The overburden was a conglomeration of broken rock, hard pan, boulders, sand, gravel, and clay. The severity of the climate made it difficult to secure the proper class of labor and the area available for dumping the spoil was small and difficult of access. When these points are considered, the record made by the contractors in handling the work and in finishing it in season to open the canal for early navigation last spring, is a commendable one.

NEW CANAL AND LOCK

The river and harbor act of March 2, 1907, empowered the secretary of war to construct a new canal and a third lock, at a cost of not over $3,000,000. This canal will be 300 feet wide and about 7,000 feet long, between the ends of the protection piers. The new lock will be

The channeled side wall, approach channel

A Sullivan "Y8" Channeler, housed for winter work

1,350 by 80 feet, and 25.5 feet deep over the miter sills. It will have a vessel capacity equal to the Poe and Weitzel locks combined, which are 800 x 100 feet and 550 x 80 feet in size, respectively.

The new lock at the Soo is parallel to the present locks and 100 feet north of the north face of the Poe lock. The improvement is shown by the dotted lines in the sketch on page 474, made up from the government engineer's drawings.

It is estimated that the new canal and lock will be in service in 1914. The excavation for the improvement is divided into four main sections. Approximately 2,400 feet, west of the international bridge, has been awarded to McArthur Bros. of Chicago, and the excavation of the lock and its immediate approaches is now being executed by the Marsh-Robbins Co. also of Chicago.

LOCK EXCAVATION

The contract for the lock excavation was awarded in August, 1909. The area within the limits of the excavation is about 2,200 feet long, 132 feet wide, and about 30 feet deep. The amount of material to be removed consists of about 142,800 cubic yards of earth excavation and 242,500 yards of rock. The overburden contained sand, gravel, timbers, broken rock, blocks of mass concrete, clay, hardpan, and boulders. The bed rock is Potsdam sandstone, in layers from a few inches to six feet thick, with scattering mud seams and pockets. The contract prices were: earth, 47½ cents per cubic yard; rock, 93½ cents; channeling, 29½ cents per square foot.

SURFACE EXCAVATION

The government had constructed a coffer dam, enclosing the area to be excavated, before work began. The Marsh-Robbins Co. were required to keep this in repair and free from water. An equipment of six electric driven centrifugal pumps, ranging from four to ten inches in size, handles the water (under 60 feet head from Lake Superior), without difficulty. A 45-ton and a 95-ton steam shovel were employed to strip the overburden, and are still in use to remove the blasted rock. The spoil is loaded by the shovels in ten car trains of 4-yard western side dump cars, and hauled to the dump by six 18-ton locomotives. The dump is due east of the pit, in the river, and the spoil is deposited from a trestle.

CHANNELING

The specifications require that the side surface walls must be channeled before blasting is done within 15 feet of the walls; and that only small charges are to be used near the walls, so as not to disturb the rock face. There are about 120,000 square feet of channeling to be done, or 8,000 lineal feet. The depth of cut ranges from 10 to 25 feet. For this work, four Sullivan "Y8" Channelers are employed, each carrying its own boiler. The progress made has averaged between 70 and 80 square feet per eight-hour shift, with a high run of 336 feet in 13½ hours on January 14, or a run 24 feet long by 14 deep. On Jan. 18 one machine cut 264 feet, and on the 14th another cut 261 feet in eight hours. The latter record was made in six hours' cutting time.

The clay and sand pockets and seamy rock have frequently reduced headway in channeling, and trouble has also been encountered from water and from the heavy side pressure after the cut is down six or eight feet. Compressed air is used to pump mud and cuttings out of the channel. Page 476 shows a channeler housed for the winter. This picture was taken in December with the thermometer 12 degrees below zero. The picture on page 478 indicates the general character of the excavation and the channelers appear in the background. Note the dip of the rock, as shown by the bedding planes. The boat is in the Poe lock, less than 200 feet away.

The new lock; Sullivan Channelers at work

Sullivan motor-driven air compressor

ROCK DRILLING

Drilling is done by 21, 3¼-inch piston rock drills, which put down nine-foot holes, bottomed with a gauge of two inches. The drills average 4.75 feet of hole per hour. The holes are spaced four feet apart on a line 35 feet long across the lock chamber. They are loaded with 14 sticks of 40 per cent dynamite. Two exploders are used in each hole and from one to 150 holes are fired at a time, by an electric battery. Within the lock limits, and wherever concrete is being placed, blast holes are stopped at least one foot above the grade, to avoid shattering the bed rock.

Great care has to be exercised in blasting, because of the proximity of the city streets, the tourists in the park adjoining the canals, and the boats passing through the locks. Fragments of rock too large to be handled by the shovel dippers, are left at one side and broken up by pop holes, drilled with Sullivan "DB19" hand feed hammer drills. There is a great deal of this work, as the rock breaks into coarse fragments. The contractors have found the hammer drills almost indispensable, since the "mud-cap" method would have resulted in heavy window breakage in the city.

To break a rock fragment 5x5x4 feet requires one hole 28 or 30 inches deep, and about ¾ pound of 40 per cent dynamite, with one exploder. For "mud-capping", at least five pounds of dynamite would be needed. The saving in explosive alone is therefore an important item. Seventy or 80 of these holes have frequently been fired at once.

The drills are operated by compressed air, furnished by a steam driven, two-stage, straight line compressor, and by a Sullivan Class "W.J" 1,200 foot two-stage compressor of the duplex, self-oiling pattern, driven by belt from a motor. (See page 478.)

The air is reheated before it is used, to prevent freezing at the drill exhausts

Sullivan Hammer Drill Rock-Setting

in the extreme weather. Three-inch pipe coils are placed in the main air lines, close to the manifold connections for the drill hose, and open fires are built around the coils, which are connected into the main with unions so that they can be moved from place to place.

Three eight hour shifts are worked, beginning at 7:00 a. m. Monday and stopping at 7:00 a. m. Sunday. The work is lighted by incandescent bulbs. Labor is obtained chiefly from the city of Sault Ste. Marie. The excavation is now about 75 per cent completed.

The contract includes the excavation of a large well, 70 feet deep by 31 feet in diameter, from which several tunnels, six by nine feet in size, run to the lock. The tunnels are from 55 to 85 feet long. Pumps, located in the well, will pump the water out of the lock at the close of navigation.

The writer is indebted to Mr. L. H. Robbins of the Mauch-Robbins Co. and to Mr. L. C. Sabin, assistant U. S. Engineer, and general superintendent of the St. Mary's Falls Canal, for information used in this article. Col. L. McD. Townsend is in general charge of the work.

048306

Sullivan Corliss Tandem Air Compressors at Firthcliffe, N. Y.

AIR COMPRESSOR ECONOMY ON THE NEW YORK AQUEDUCT

The Catskill Aqueduct, for supplying New York City with water, is notable for its length, 150 miles, its ultimate cost, about 160 millions of dollars, and the engineering difficulties encountered in its construction.

The hilly country through which the aqueduct runs has made necessary the boring of numerous tunnels through solid rock. The contractors on these sections have installed construction plants comprising, in many instances, equipment of the highest grade and most economical type. This is particularly true of the air compressor installations, since air power is employed in very large amounts, for running rock drills, concrete mixers, pumps, and other machines.

A compressor plant of unusual interest to engineers is that of the Mason and Hanger Company, at Fitzhliffe, New York, near Cornwall-on-Hudson. This firm holds the contract for driving the Moodna siphon or pressure tunnel. Their plant consists of four Sullivan tandem corliss two stage air compressors, each with a piston displacement of 2,450 cubic feet of free air per minute, at 100 revolutions, providing a total capacity of nearly 10,000 cubic feet. The steam cylinders are 20 and 34 by 30 inches and the air cylinders 18 and 30 by 30 inches in size. Both the high and low steam pressure cylinders are equipped with full corliss valve gear, the knock-off cams being actuated by dash pots. The point of cut-off is automatically varied by means of a co-ordinating speed and pressure regulator, which is dependent on both the steam and air pressure for its action.

The air cylinders are fitted with rotary inlet valves, mechanically driven, and with automatic, air cushioned, poppet discharge valves. Unusually large water-jacket and intercooler area secures the highest possible benefits from compressing the air in two stages.

The tandem arrangement of the cylinders in these compressors renders them very desirable for contractors' use. The photograph on page 480 shows the small house room occupied by these four units. Cross compound machines of the same capacity and steam economy would require about twice the foundation and floor space, and at least double the expense and time for installation.

Each of these compressors weighs about 41 tons, and the ease and rapidity with which this heavy machinery was set up and placed in running order in the Mason and Hanger plant was remarkable. As these machines are practically self-contained, they may be moved from one job to another with little difficulty and at low cost, compared with other types. By purchasing several of these units rather than one or two very large compressors, the owners have secured higher operating efficiency than would otherwise be possible. If not enough air is required to keep the whole plant busy, two or three units are kept running at full load and efficiency, the variable load being handled by one of the remaining compressors. A single large unit, under such conditions, would be obliged to run at only part of its rated capacity, with a consequent drop in efficiency.

This compressor plant takes steam at 140 pounds throttle pressure, from water tube boilers, burning anthracite coal under forced draft. The condensing plant is of the central barometric pattern. No reasonable expense was spared to make this plant as economical as possible in operation, and some excellent records in efficiency have been secured. These four compressors are used by the Mason and Hanger Company for supplying air at 110 pounds receiver pressure to the five shafts and nine working faces, by means of which they are driving the Moodna Siphon.

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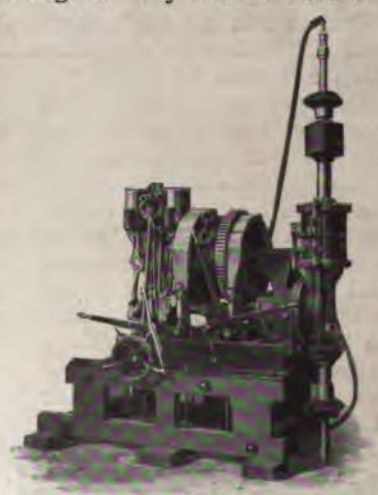

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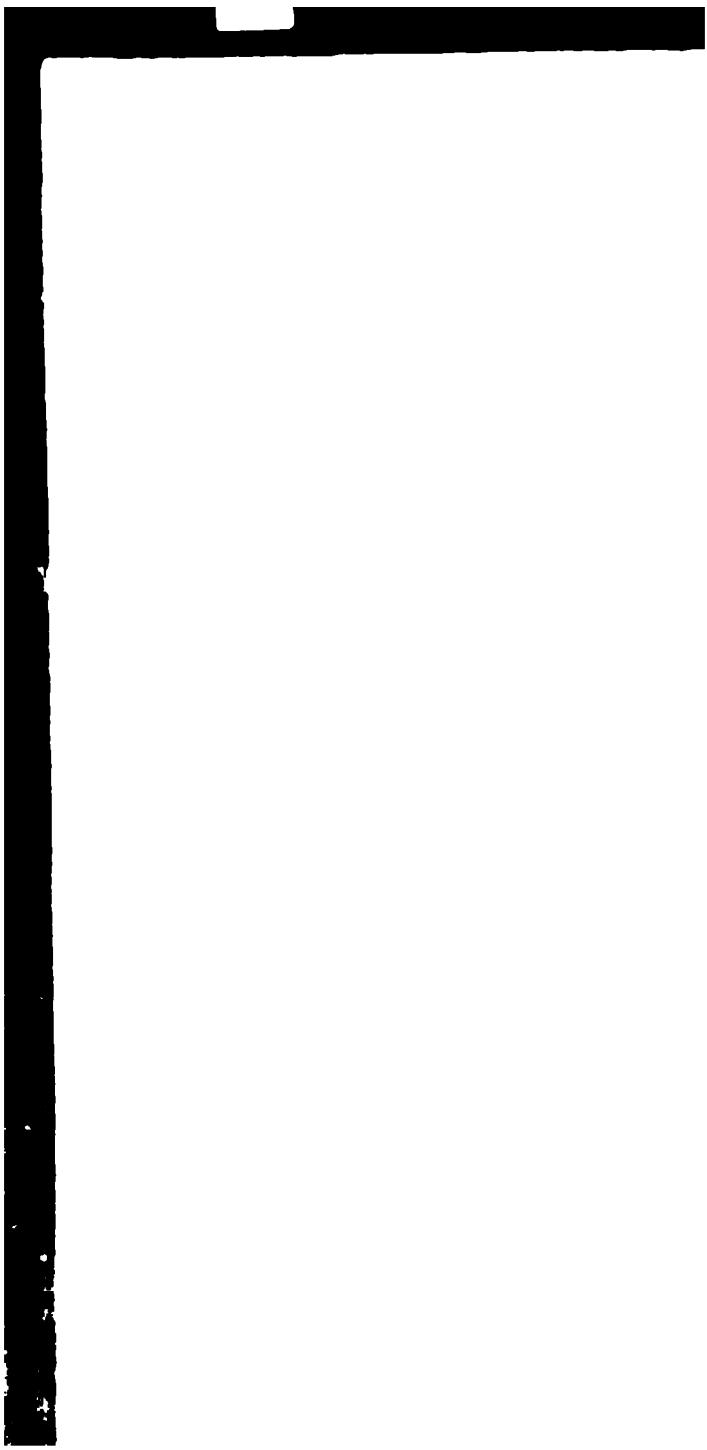
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